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**University of Strathclyde
Department of Computer and Information Sciences**

**Supporting Members of Online
Communities Through the Use of
Visualisations**

**By
Rehman Mohamed**

**A thesis presented in fulfilment of the requirements
for the degree of Doctor of Philosophy
2007**

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Abstract

Growing numbers of people around the world are using online communities to stay in touch with each other. Online communities are now widespread, enabling meaningful communication, around various domains of interest, between users who are separated by time and distance. Despite the increasing numbers of people using online communities, there are many examples of communities which suffer from problems of falling levels of contributions from members.

This thesis investigates the main principles involved in creating successful online communities. It develops a taxonomy of community interactions that provides a framework for investigating techniques that have the potential to encourage member participation. Within standard text-based online communities, problems of information overload can be prevalent, with extensive user participation often required in order to get an overview of the interaction environment and context.

This thesis proposes the use of facilitation techniques, in the form of visualisations, as a means of helping users get a better understanding of the interaction context, reducing the amount of time spent by users in the information-discovery phase. A range of new, complementary visualisations are developed and tested in order to assess their efficacy in helping users to complete tasks that they would be likely to undertake during their information-discovery phase. The results of the experiments show that not only do visualisations help users achieve more accurate results in conducting simple information-discovery tasks, but they also help in completing such tasks in a more efficient manner, shrinking the amount of time spent in the information-discovery phase. Different visualisations are also shown to be more useful in different circumstances, pointing to the fact that the needs and requirements of users, and the tasks they undertake, should be considered when designing the exact nature of any potential visualisation intended to support users of online communities.

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Chapter 1 Introduction

1.1 Context and Motivation

The number of people using the Internet is continuing to grow at a fast pace. In the United Kingdom, there are reported to be around 37 million Internet users (approx 60% of the population), and usage of the Internet has grown by nearly 150% since 2000 (Internet World Stats, 2007). At the time of writing, there are estimated to be almost 315 million people using the Internet across Europe, with the number of people using the Internet doubling since 2000¹. Over 1,000 million people use the Internet worldwide. Given the growth in Internet use, it is not surprising to find reports of rising numbers of people using online communities. The Pew Internet and American Life Project surveyed Internet users, finding that 84% used the Internet to find out about a community and, of those, 79% stay in contact with at least one community on a regular basis (Horrigan, 2001). Hundreds of millions of people from across the globe take part in online communities for a range of different purposes. Online communities are now widespread and form useful forums, unrestrained by geographical boundaries, for groups of people who identify and interact around common, purposeful and mutually beneficial interests.

Despite the growing numbers of people using online communities, there are many examples of communities that face problems of withdrawal and attrition, and ultimately fail due to lack of involvement from users (Haythornthwaite et al, 2000; Johnson, 2001). Because of this, a key challenge lies in developing instruments which can act as a facilitator, encouraging contributions from users and raising levels of communication and feelings of kinship in a manner that enables interaction between members and reduces barriers that lead to lack of involvement and community stagnation.

A rise in contributions from users should create more successful and sustainable online communities. This thesis examines methods of community support, with the

¹ These latest Internet World Stats figures were updated on 10th March 2007

aim of providing environments that facilitate and promote social interaction. Visualisations are proposed as a potential driver towards this goal.

Communication is at the core of online communities, with collective action, exchanges of social support, and sense of community rooted in the conversations that members of the community have with each other (Ginsburg & Weisband, 2002; Culnan, 2006). Without contributions and exchanges between users, there would be no sense of community (Girgensohn & Lee, 2002). If there is a dearth of contributions in an online community, there will be insufficient interaction to sustain and maintain the interests of members. A critical mass of activity is required in order to encourage existing members to continue to interact, as well as to attract contributions from new or previously passive members (Preece, 2000). Increased participation from users should help towards achieving this critical mass. Engendering a sense of community can be helped through repeated social interactions that increase familiarity and strengthen relationships between users.

When a user first joins an online community, they typically seek a quick overview of community content (Wenger, 2003; Preece, 2004). This level of activity often involves browsing the web pages and message boards in order to find out whether the community meets their needs and will be of interest to them. During this information-discovery phase, a user takes a passive role in the community, searching for resources or topics of interest, and looking for other users with similar interests (Preece, 2000; Warms et al 2000b). However, in cases of communities with poor levels of contributions, many members fail to progress from this passive information-discovery phase, and do not move towards becoming more active contributors to the community (Soroka & Rafaeli, 2006).

The concept of community is normally associated with interaction and shared co-presence, whereas the typical contact between a user and a website is on the whole a solitary experience, with limited visual clues indicating the presence of other participants and their activity (Wexelblat, 1999; Dieberger et al, 2000; Svensson et al, 2001). Extensive user participation is often required in order to get a holistic view

of the interaction environment and context. Given that it can be difficult to contextualise the interactions that are taking place, a user's information-discovery phase is often longer, with prolonged membership required in order to find topics of interest and identify the key or leading members of the community (Hattori et al, 1999).

This thesis proposes that the provision of facilitation techniques can help users get a better understanding of the interaction context, shrinking the amount of time spent in the information-discovery phase, and alleviating the problems of information overload that can be prevalent within standard text-based online communities. Visualisations are proposed as one such facilitation technique, and a novel set of matching interest and bulletin board visualisations are developed and evaluated in order to assess their efficacy in supporting different kinds of typical online community interaction.

1.2 Hypotheses

Existing research shows that online communities can be augmented through the use of visualisations. However, much of this research fails to examine the efficacy of these visualisations in helping users complete tasks that they would be likely to undertake in their use of online communities.

Both the matching interest and bulletin board visualisations developed in this thesis are assessed as a means of testing their efficacy in not only helping users complete such tasks, but also in reducing the amount of time spent during the information-discovery phase. This thesis seeks to test the hypothesis that, for simple tasks conducted during the information-discovery phase, visualisations help users achieve more accurate results. Furthermore, this thesis tests the hypothesis that visualisations help users complete such tasks in a more efficient manner. The hypothesis that specific visualisations are more helpful in completing certain tasks is also tested. The null hypotheses for each of these can be stated as follows:

Hypothesis 1

H₀: Visualisations do not help users of online communities find more accurate information in simple information-discovery tasks

Hypothesis 2

H₀: Visualisations do not help users of online communities to complete information-discovery tasks in a more efficient manner

Hypothesis 3

H₀: No particular visualisation is any more helpful in conducting simple information-discovery tasks

The first hypothesis tests whether the use of visualisations helps users achieve more accurate results for tasks that they would be likely to conduct during the information-discovery phase. The second hypothesis tests whether visualisations help users complete these tasks in a more efficient manner. Given that this thesis develops a range of complementary visualisations within both the matching interest and bulletin board systems, the third hypothesis seeks to test whether any individual visualisations are more helpful to users in completing specific tasks.

1.3 Contribution of this Thesis

This thesis makes the following contributions :

- **Develops a taxonomy of users' objectives.** Existing research outlines the common objectives and tasks that users of online communities seek to satisfy. This thesis develops the existing work into a taxonomy that highlights and conceptualises the spectrum of different activities that users of online communities can be involved in, ranging from short-term information-discovery objectives through to medium and long-term objectives in which users become more active participants in the community.

- **Shows that visualisations aid users to complete simple information-discovery tasks.** Much of the existing research fails to test the efficacy of their visualisations in helping users carry out simple tasks that would normally be conducted during the use of online communities. This thesis addresses this shortcoming by testing the visualisations developed herein within a series of user experiments which prove the visualisations to be useful in helping users complete simple information-discovery tasks.
- **Shows that visualisations can be used to reduce the amount of time spent in the information-discovery phase.** This thesis shows that not only do visualisations help users achieve more accurate results in conducting simple information-discovery tasks, but they also help users complete these tasks in a more efficient manner, thus shrinking the amount of time spent in the information-discovery phase.
- **Shows that different types of visualisation are more useful in different circumstances.** This thesis tests the visualisations in a range of different circumstances and the results show that rather than one particular visualisation being more helpful, different visualisations are more helpful for different types of task.

1.4 Structure

This thesis investigates the use of techniques that can support users of online communities. Chapter 2 conducts an extensive review of the literature on online communities. It considers the concept of community before examining the main features of online communities, and the primary principles involved in their design. Building on existing research into the type of interactions that take place within online communities, a taxonomy of user objectives is developed. This taxonomy gives a structure to the series of different activities that users of online communities can typically be engaged in, ranging from short-term information-discovery objectives towards more medium and long-term objectives that see users contribute to the community and become more active participants. The review highlights that the primary challenge in creating sustainable online communities lies in encouraging

more members to become active participants who make more contributions over an extended period of time. One means of encouraging further contributions from more passive members is to reduce the investment of time and effort required from users before they feel comfortable in participating. Therefore, this chapter proposes the use of simple visualisations that augment online communities, shrinking the amount of time that users spend in the information-discovery phase, and acting as a possible driver towards encouraging further contributions from users.

Chapter 3 reviews the growing body of research into the use of visualisations as a means of supporting users of online communities. The problems faced in using current text-based communities are examined, before highlighting the power of visual representations and how this can be harnessed within the design of visualisations aimed at supporting online communities. A range of existing visualisations within the primary areas of matching interests and bulletin boards are critically examined, highlighting a range of shortcomings in these current approaches.

Chapter 4 addresses the deficiencies of the existing visualisations discussed in the preceding chapter, and progresses this work by introducing the new and novel matching interest and bulletin board systems that have been developed as part of this thesis. The various design principles of both sets of visualisations are considered, before highlighting how the new visualisations improve on existing work. In both the matching interest and bulletin board systems, a series of three different complementary visualisations are developed in order to allow users to view the same data from a range of different perspectives, based on the users' circumstances, needs and requirements. The various experimental hypotheses are discussed before considering the type of tasks that users were asked to undertake during the experiments.

Chapter 5 outlines the methodology used in testing the experimental systems. The experimental domain is introduced before presenting a more detailed examination of the methodology behind the experiments.

Chapter 6 presents the results of the user experiments which were carried out on both the matching interest and bulletin board systems. In addition to testing whether the visualisations help users complete a series of simple tasks that they would ordinarily undertake as part of their information-discovery phase, the efficacy of the visualisations in helping users complete these tasks in a more efficient manner is also tested. The experiments further test whether specific visualisations are more effective in assisting users in the completion of different tasks.

Chapter 7 discusses the results of the experiments within the context of this thesis and related literature. For both the matching interest and bulletin board systems, the results are discussed with respect to the experimental hypotheses across all the experimental tasks, before considering feedback from users. The implications of the findings, in terms of the general usefulness of visualisations within online communities are discussed, before considering the limitations of this research. Areas for future work which build on this novel research are outlined, detailing ways in which the additional work can further contribute to knowledge.

Chapter 8 completes this thesis, presenting the key conclusions and summarising the main contributions of this research.

Chapter 2 Online Communities

2.1 Introduction

There is a growing body of research into online communities. This chapter reviews this literature, examining the concept of community before focussing on the primary differences between physical face-to-face communities and online communities. The main elements and design principles relating to online communities are then discussed, focussing on issues relating to people, purpose, policies and computer systems. The review continues by considering various ways to gauge the success of an online community using both qualitative and quantitative measures.

Building on existing research into the type of interactions that take place within online communities, a taxonomy of user objectives within online communities is proposed. This taxonomy is useful in helping to conceptualise the spectrum of different activities that online community users can be involved with. The review continues by showing that the primary challenge in creating sustainable online communities lies in encouraging more members to become active participants who make more contributions over an extended period of time. One way of encouraging further contributions from more passive members would be to reduce the investment of time and effort required from users before they feel comfortable in participating. This chapter concludes by proposing the use of simple visualisations that augment online communities and act as a means of encouraging further contributions from users.

2.2 The Concept of Community

Communities are widespread throughout human society and are found all around the globe. Communities come in many different shapes and sizes, and serve many different purposes. As outlined by Morris & Hess (1975), we all live someplace - we are all members of communities.

Communities have boundaries, but these boundaries are fluid in many ways. For example, Glasgow may be considered to be a community. In turn, Glasgow is composed of many areas or neighbourhoods, each of which can be thought of as an individual community in its own right. Similarly, Glasgow is part of larger regional, national and global communities. Glasgow is a city in the west of Scotland. Scotland is part of the United Kingdom which, in turn, is a member of the European Community, and so on.

Community exists in both a geographical and relational sense, and the two are not mutually exclusive (Gusfield, 1975; Worsley, 1991). In addition to location-based communities, people can be members of political, ethnic, religious or professional communities, participating in more than one community at a time. The world does not neatly divide along any lines that are drawn. The membership of communities is fluid as people move in and out of them. People can be members of many communities, serving a wide variety of roles within these different communities, and they can easily move from community to community in order to pursue their interests. Furthermore, experience within an individual community is context specific and may vary between members (Sonn et al, 1999). Due to the large size of communities, many members may not interact with one another, or even be aware of each other. However they will still recognise each other's membership within the community (Preece et al, 2004).

Gherardi and Nicolini (2000) noted that community knowledge was synergistic, with the sum of the community knowledge being greater than the sum of individual participant knowledge. This symbiosis is emphasised by the fact that the collective knowledge of a community advances while simultaneously advancing the knowledge of individual users within that community (Bielaczyc & Collins, 1999). There will be some interdependence amongst members, but no single member is essential for the survival of the community as a whole.

Schuler (1996) outlined three uses of the word 'community': (1) A group of people who live together in the same geographical locale. (2) A group of like-minded

people. (3) A state of togetherness, group communion and mutual concern. In addition to face-to-face communities which tend to congregate in a geographical locale, communities of like-minded people with collective concerns and interests are recognised, and the Internet has enabled these people to gather as members of online communities.

2.3 Face-to-Face v Online Communities

There is a sense of community where members have a sense of belonging to a greater social unity. In addition to the concepts outlined by Douglas Schuler, the use of the Internet to develop online communities has meant that localised communities can now have a more global outlook, and other more globally dispersed communities can now come together to collaborate and exchange information to a previously unprecedented degree (Wenger & Snyder, 2000). “Virtual communities are cultural aggregations that emerge when enough people bump into each other often enough in cyberspace. A virtual community is a group of people who may or may not meet one another face-to-face, and who exchange words and ideas through the mediation of computer bulletin boards and networks” (Rheingold, 1994, pp. 57-58). Online communities enable meaningful communication between users who are separated by time and distance. They include users who are actively interested in, or associated with, a group formed around a particular domain of interest or mutual concern.

Ferdinand Tönnies defined "Gemeinschaft", or community, as small geographically distinct, kinship-interwoven groupings characterised by intimate, overlapping, and stable relationships. The concept of community has evolved since then and communities are now defined in terms of social relationships, rather than in terms of space. Modern societies tend to develop more relational communities (Durkheim, 1964; Royal & Rossi, 1996) or communities of the mind (Tönnies, 1955), and it is these communities that tend to form online (Surratt, 1998; Obst et al, 2002).

The Internet enables the development of online communities where members communicate entirely through computer-mediated communication and never actually

meet face-to-face, and these communities have been identified as ‘real’ in a sociological sense (Suratt, 1998). People are becoming increasingly accustomed to thinking of the online world as a social space, with an unprecedentedly large number of people keeping in touch with each other via electronic media (Donath & Boyd, 2004). Members of online communities tend to refer to it as an architectural place, and to the mode of interaction in that space as being social (Stone, 1991).

According to a 2001 Pew Internet & American Life Project, 84% of Internet users indicated that they were a member of an online community and 79% identified at least one community with which they maintained regular contact online (Horrigan, 2001), whether this be for collaboration, support, information or debate. The demographic composition of the user population is widespread, including people of all ages, cultures, educational backgrounds, experience and technical skills. Members of online communities come from all walks of life, and communicating online is increasingly becoming a normal part of people’s lives, particularly for younger people (Preece & Maloney-Krichmar, 2003). Hundreds of millions of people find friends (Parks & Floyd 1996), information (Joyce & Kraut 2006), education (Graddol 1989), fun (Ducheneaut et al. 2006), and support (Preece, 1999) in online communities on a regular basis. Many people also use the Internet to maintain and extend contact with local groups, and Wellman (2002) used the term “glocalization” to refer to the use of the Internet to expand users’ social contacts and bind them more closely to the place where they live. One example of glocalization is ‘Craigslist’². Founded by Craig Newman in 1995, it features free classified advertisements and a range of forums covering areas such as jobs, housing, personals etc. Since initially launching for the San Francisco Bay Area, Craigslist has expanded and is now established in approximately 450 cities around the globe.

Online communities are now widespread and form useful forums, unrestrained by geographical boundaries, for groups who identify and interact around common, purposeful and mutually beneficial interests. Online communities are dynamic, constantly changing systems. They exhibit ‘organic’ growth (Jung & Lee, 2000),

² <http://www.craigslist.org>

evolving through different phases, reflecting changes in the needs of their members, changes in the social setting, or changes in the support infrastructure (Malhotra et al, 1997; Liedka, 1999; Squire and Johnson, 2000).

Online communities typically have a varying purpose or focus, ranging from supporting business practices via a community of practice, to distance learning, to continuing professional development or to sharing a common interest such as movies (Mohamed et al 2002; Mohamed et al, 2004c). Online communities will mean different things to different people; each member may have diverse objectives, even if all members share common interests (Hattori et al, 1999). This thesis considers principles that are applicable to online communities in general rather than narrowly focusing on the individual requirements of specific types of online community such as communities of practice or learning communities. Nevertheless, the principles and elements outlined herein should prove generally applicable across the different domains of communities that exist predominantly online.

2.4 Main Elements of Online Communities

There is a growing body of research on what constitutes an online community. Much of this research proposes different interpretations and definitions of the term. However, there is also a broad agreement that there are core elements that are needed in order to form a successful, lasting online community. Preece (2000) provides a frequently-cited definition that lists four required elements of online communities:

- *People*, who interact socially as they strive to satisfy their own needs or perform special roles
- A shared *purpose*, such as an interest, need, information exchange, or service that provides a reason for the community
- *Policies*, in the form of tacit assumptions, rituals, protocols, rules and laws that guide people's interactions
- *Computer systems* to support and mediate social interaction and facilitate a sense of togetherness.

This definition highlights the interdisciplinary nature of online communities while emphasising the social aspects. People must interact socially around a common interest or purpose, and follow rules that guide their interactions, using systems to facilitate togetherness.

The success of an online community is dependent upon usability (through well-designed software), sociability (through sound social policies), and the effect of these attributes on the interactions of the community members (Lazar & Preece, 2002). This social emphasis has a historical basis. A cornucopia of research on online communities has focused on how online communication compares to face-to-face interaction in terms of the decisions groups make (Kiesler et al, 1984), the relationships people form (Parks & Floyd, 1996), the psychological well-being of participants (Kraut et al, 1998; Kraut et al, 2002), the kind of language people use (Herring, 2003), and other aspects of how online communication affects social behaviour. The vast majority of online communities rely upon users' voluntary commitment, participation and continued contributions. They need members to return, interacting with others to maintain the community infrastructure, generate new and updated information, and provide social and emotional support to other users. People, purpose, policies and systems will now be considered.

2.4.1 People

The Internet is increasingly being used to generate a sense of belonging (Hiltz & Wellman, 1997). For example, many spouses now use e-mail to communicate when one or both are travelling, and parents are now exchanging e-mails with their children attending college or university. The Internet is increasingly being used in the same way as letters and telephones were previously used to sustain traditional community relationships, and participation in online communities is progressively becoming a normal part of many people's lives (Raine & Packel, 2001).

Real-world communities have traditionally been location-centric and had membership according to norms, with individual expression sometimes being overridden by group dynamics. There is usually a distinct membership with it being easy to recognise who is a member and who is not. In contrast, online communities tend to be organised around a purpose or idea rather than a place; they provide a medium whereby members can meet and communicate with each other (Preece, 2000). The membership of online communities tends to be fluid, and can form as a need or purpose arises (Squire & Johnston, 2000). Given that members of online communities cannot see each other, they do not tend to be dominated by norms as much as traditional real-world communities, thus enabling greater individual control. Some people may also find it easier to express themselves in writing and they can find their voice when conversations move online.

Online communities tend to be larger, more densely knit and more dispersed in time and space than off-line communities. "The Net erases boundaries created by time and distance, and makes it dramatically easier for people to maintain connections, deepen relationships, and meet like-minded souls that they would never have met" (Kim, 2000, p.x). Online communities tend to have members with more heterogeneous social characteristics (Carroll & Rosson, 2001) but with more homogeneous attitudes (Hiltz & Wellman, 1997).

Community is increasingly a sense rather than a tangible entity (Wiesenfeld, 1996; Brook & Oliver, 2002). McMillan & Chavis (1986) define this sense of community as a "feeling that members have a belonging, members matter to one another and to the group, and a shared faith that members' needs will be met through their commitment to be together" (p. 9). Communities are about people, identity, objectives and common interests.

Cothrel & Williams (1999a) found that the social element was critical to distinguishing a community from a mere group of individuals. Communities are groups of people who identify and interact around common, purposeful and mutually beneficial interests, and are guided by norms and policies (Preece, 2000). There is

also evidence that the sharing of some personal information promotes interpersonal bonds, even among people who have not yet interacted (Walther, 2002), and this can increase the likelihood of future interaction between users. For example, the inclusion of members' home locales enables others to identify those who live in the same region.

Each community is unique and, as such, there is no single method that assures a community will be successful. Just as Glasgow, Scotland is different from Orlando, Florida, online communities are also very different from each other. The population of Orlando increases at different parts of the year as tourists visit Disney and other theme parks. The same issue of population stability affects online communities. Some online communities are stable, with a large percentage of people who have been members for a long time, while other communities have populations that turn over rapidly (Lazar & Preece, 2002). For example, the composition of e-learning communities changes with each new intake of students and has 100% turnover every few years.

Communities generally outlive individual members, and the continued membership of individual members is generally less important than the survival of the community. Some members will disappear and others will join later. Communities do not have predetermined lifespans; they will generally last as long as there is a need from the individual members.

Communities are dynamic and are constantly changing and evolving. The central issues surrounding communities are people issues - web technology merely acts as a facilitator, providing the supporting infrastructure to help people come together and fulfil their purpose (Cothrel & Williams, 1999a).

2.4.2 Purpose

Cothrel & Williams (1999a) conducted a study of 15 online communities of practice. They found that several respondents believed that the purpose of the community was

to share knowledge. They concluded that if a community is to be successful and allowed to develop, the members must have a shared passion and be willing to openly share information amongst themselves.

In order to be successful and deliver true value to the users, the aims of the community must be clear. The first step is to understand the purpose of the community (Kim, 1998; Palloff & Pratt, 1999; Maloney-Krichmar & Preece, 2005). Only once the motivation is understood can real value be delivered to the target audience. Defining the purpose of a community is important for potential members to know what to expect (Lazar & Preece, 1998). There may be highly motivated people who will be prepared to browse web pages and message boards, but the vast majority of new users want to immediately find out whether a community meets their needs and is worth joining. If users do not find immediate value in their participation, they will be less likely to return and become a part of the community.

Each community needs a purpose; there has to be a distinctive focus, which gives the community a purpose to exist. Sharing a common purpose is the best first step to building a loyal community of members. It is vital to tap into this collective community-enabled purpose rather than focussing on individual goals (Kim, 2000). Online communities grow and thrive when members are able to fulfil their purpose and accomplish those goals that require other members to participate. The concept of collaborative purpose is one of the web's premier strengths as a means of building community (Real Communities Inc., 2000). Even though the Internet provides exposure to diverse groups and ideas, people are most strongly drawn to online groups that share their interests and concerns (Preece, 2000; Wellman & Frank, 2001).

The use of the Internet to link individuals with others sharing common interests provides the scaffolding for building communities that offer support, solidarity, information and social capital (Wellman & Frank, 2001). When people meet in a real-world setting, they are likely to do so because they share an interest. The same applies to people interacting online – they will have a shared purpose, goal, interest

or experience. It is this shared interest or purpose that fosters a sense of community and enables social groups to emerge (Harrison & Dourish, 1996). An online community needs to have a presence in the lives of its members. Offering content that is focussed on the primary interests of the users is the hook that attracts members to an online community (Andrews, 2002). If members identify with the domain of the community, they will then have a long-term commitment to its development.

Social interaction within an online community is governed by the collective purpose of the community, the goals and roles of individual members of the community, and the policies generated to shape social interaction. When the collective purpose of the community is in line with the goals of individual members, this will help to foster a sense of community and generate social interaction.

Each community will have a different purpose, whether it is to support business practices via a community of practice, to aid students via distance learning, to discuss money saving tips, or to talk about football. Within the social framework of the community, users aim to satisfy their own needs (Carroll & Rosson, 2001), and whether they actively contribute to the good of the community or are there just to indulge themselves depends upon the community's policies and individual personalities. Through careful communication of a community's policies and purpose, the development of a community can be positively influenced (Preece, 2000).

2.4.3 Policies

If an online community is to be successful, it must be built upon solid foundations. "Web communities need 'social scaffolding' to grow and thrive. Social scaffolding refers to those aspects of a site - roles, rituals, features, events, and leadership - that facilitate community development. Much like a trellis enables a plant to grow, social scaffolding enables members to become progressively more involved in the community" (Kim, 1998). Simply launching a web site with a bulletin board and chat facilities does not automatically generate a community (Mager & Karlenzig, 2001).

It is possible to draw an analogy between a solid community and a good party. The sign of a good party is that the host can leave the room and the conversation continues. Communities cannot survive without upkeep. Just as cities need town planners, tourism bureaux, police, and public services, online communities need maintenance and support as well. New members should be welcomed and introduced to the community's goals, norms and etiquette. It is not unusual within communities for content to be monitored by moderators who review, revise, or reject contributions that do not fit the group's purpose. In an ideal world, the needs of members are congruous with those of the online community, but inevitably this is not always the case and policies are required to ensure harmony, whilst at the same time deal with any serious transgression.

Registration can help to control the number of people who join the community, and can engender a sense of trust between members and the community. Requiring registration information ensures at least minimal identification of community members. Registration needs to be substantial enough in order to deter troublemakers, while being minimal enough that potential members are not scared away due to privacy concerns. Many users are wary of divulging personal information but these concerns can be overcome by employing a sound privacy policy and making the use of the information transparent to the user within the terms and conditions of membership (Preece, 2000). Trust and security are important in any type of online community because, in order to be able to communicate freely, users must feel reassured that their privacy is being protected.

Members are more likely to disclose further information if they are aware that the information they provide will be kept private and only used to help provide better services within the community. Trust can be built up by only asking for minimal information upon registration, with members having the opportunity to create a progressively more detailed profile as they become more comfortable with the community (Kim, 2000). Greater trust of member and community expertise will increase participation in the community (Ridings et al, 2002). As people start to

develop a shared sense of belonging, interactions with other members increase. Issues of trust are obviously more important in some communities than in others. For example, users of health-related and medical communities that deal with sensitive information will place a greater emphasis on trust and security policies before feeling that they can contribute freely to ongoing conversations.

Preece (2000) uses the term 'sociability' to refer to social policies that encourage development of congenial and appropriate social interactions. Some policies and social protocols are widely known and accepted by most established Internet users, but some others may be specific to a particular online community. Communities with good sociability have social policies that support the community's purpose and are understandable, socially acceptable, and practicable. Appropriate and responsible moderation, stable leadership, and an appropriate level of registration can positively influence the sociability of the community.

Discussion boards often have moderators who have the power to approve and reject contributions, while many communities such as Craigslist and Wikipedia³ encourage members to report various kinds of abuse. Successful moderation and policies play a key role in maintaining a community's purpose, and the policies must be shaped and continually developed in order to encourage commitment and continued contributions from members. A healthy alternative to setting rules is to encourage users to communicate more effectively in order to minimise misunderstandings or frustration. Helping users to convey the meanings of their correspondence in a more effective manner can help to reduce any potential ambiguity (Lazar & Preece, 2002).

Many online communities exhibit an excellent level of self-management while others need to be shaped, and require a significant investment of time and effort to maintain (Cothrel & Williams, 1999b). Many online communities need to be managed, either formally or informally, especially in their embryonic stages. Cothrel & Williams (1999b) found that the effort required in maintaining a community is almost always greater than the effort required to launch the community. The need for a leadership

³ <http://www.wikipedia.org/>

structure will grow as the community grows. As hot spots develop within the community, there needs to be a mechanism for managing and dealing with the increase in traffic.

Effective leadership programmes will evolve with the member base. When members are willing to help the community thrive by acting as leaders, experts, information sharers or mentors, this indicates that the community is something that people value. A sign of a thriving online community is that members are willing to adopt an informal role in supporting and promoting the community. Enthusiastic volunteers can often prove to be the best moderators because they are doing it out of love rather than for money (Kim, 2000). When members become actively involved in community moderation and standards, the virtual social networks of an online community become self-sustaining (Postmes et al, 2000; Preece, 2000; Andrews, 2002). While some regular visitors to the community space may be readers or observers, enthusiasts actively contribute to the community by making thoughtful contributions to debates, or through making sound suggestions for events. By spotlighting these enthusiasts and their useful contributions, this should encourage further similar contributions from the wider community.

Community members may be reluctant to participate in ongoing conversations or more intense topics (Rossman, 1999). Facilitators or moderators can enhance the community by fostering member interaction, providing stimulating material for conversation and helping members adhere to the stated guidelines, rules or norms of the community (Salmon, 2000; White, 2001). "Good hosts are invaluable; they welcome new members, keep discussions on-topic, and deal with troublemakers" (Kim, 1998). Moderators should promote free discussion, encouraging members to build a sense of community. As communities mature, some conversations may start to recycle as new members join. Moderators serve a key role in regularly starting new conversations and threads, so that a range of members can be engaged or re-engaged.

Community moderators and hosts should also enforce any community standards, codes of conduct and policies. Community members should agree to the terms and conditions of membership of the community prior to registration and it is the role of the community moderators to enforce these rules. The ethos and norms of the community serve a key function in building up trust with the members. By enforcing these rules, the community establishes and maintains credibility with the members (Kim, 1998; 2000).

2.4.4 Computer Systems

Howard Rheingold wrote of his experience with the WELL, an online community developed in the Bay area of San Francisco. "In cyberspace, we chat and argue, engage in intellectual discourse, perform acts of commerce, exchange knowledge, share emotional support, make plans, brainstorm, gossip, feud, fall in love, find friends and lose them, play games and metagames, flirt... We do everything people do when people get together, but we do it with words on computer screens, leaving our bodies behind... our identities commingle and interact electronically, independent of local time or location" (Rheingold, 1994, p. 58).

Communities and social networks are held together by social capital (Preece, 2002). Social capital is the social equivalent of financial capital and, like financial capital, is a resource that helps sustain a community. Social capital encourages collaboration and cooperation between members of groups for their mutual benefit, incorporating the trust, social interactions, and norms of mutual reciprocity throughout a community (Coleman, 1990; Carroll & Rosson, 2001). Communities that are rich in social capital are more likely to thrive and be sustainable. Such communities tend to communicate well, their members spend time together, they help each other, and members contribute to the collective common good. Growing maturity in online community systems and technologies has dramatically lowered the effort required for members to participate, and when participation is easier, more people participate (Warms et al, 2000b).

The computer systems and technologies associated with online communities can be used as a catalyst to sustain and foster social capital, enabling members to communicate with each other. In order to do this, the software must support sociability, enabling effective social interaction online (O'Day et al, 1998; Smith & Kollock, 1999). Interaction via technologies such as bulletin boards and online forums provide a good starting point for extending community development, enabling users to reflect, compose and review correspondence at their own convenience using asynchronous text environments (Preece, 2002). While such systems do not guarantee a successful online community, well-designed software can help contribute towards making a successful community even more successful (de Souza & Preece, 2004).

The bandwidth of users' Internet connections has been steadily increasing in recent years, enabling some people to communicate through video-conferencing. Allied to this increase in bandwidth, there has also been an increase in the data volumes that people want to send (Donath, 2004). However, there are still limitations associated with technologies such as video conferencing, and there can be problems of having sufficient bandwidth to both send detailed images and to send them without delay. Furthermore, despite conveying some non-verbal communication such as facial expression and voice tone, there are still of limitations of bandwidth, and allied to issues of screen size and resolution, there are some non-verbal cues that are lost, including subtle body language, contextual information about participants' moods and information about the environment in which they are participating (Olsen & Olsen, 2000).

Perhaps more importantly, many members of online communities still use dial-up connections. Therefore, despite the increases in bandwidth, there are still limiting factors within online communities which preclude the uptake of more technologically sophisticated means of communication. These factors cannot be ignored when attempting to ensure universal accessibility to online communities. Allied to this, it is important for online communities to avoid long download times that annoy users (Nielsen, 2000). Although users' tolerance of download times is

ultimately dependent on how much they want the information, research indicates that users' perception of content value is influenced by download time and this can severely test their patience (Sears et al, 1997; Ramsay et al, 1998). A further detrimental impact of extended download times is that some users may also perceive that they have made an error (Lazar & Norcio, 2000). Therefore, although there have been increases in bandwidth, online communities are still predominantly limited to existing text environments.

As online communities continue to develop and evolve, only the software that supports them is designed. Therefore usability of this software is central to the issue of whether users are able to communicate with each other, find information and navigate easily through an online community. Usability is well-established in human-computer interaction design (Preece, 1993; Nielsen & Mack, 1994; Preece et al, 1994; Hackos & Redish, 1998; Shneiderman, 1998; Mayhew, 1999; Preece et al 2001), and is concerned with developing computer systems to support rapid learning, high skill retention, and low error rates. Such systems support high productivity; they are consistent, controllable, and predictable, which makes them pleasant and effective to use (Shneiderman, 1998).

If users cannot even figure out how to join a community, there is little chance that they will eventually become members of that community. Online communities compete with other priorities in the lives of their members. Therefore, good usability is necessary to keep members in a community, and encourage contributions and participation from those members. If users have to spend time figuring out how to post a message, this is likely to discourage further contributions (Lazar & Preece, 2002). When something is made easy, people are encouraged to do it more often, and when something is made hard, people are discouraged and do it less often.

Just as the input of users is necessary in order to ensure a successful information system (Norman & Draper, 1986), the same is true of the design of online communities. Community-centred design involves community members, or potential community members in the design process, developing community policies, selecting

software, and performing usability testing (Preece, 2000). Community-centred design has been successfully used in the development of a number of different types of online communities (Lazar & Preece, 1999; Lazar et al, 1999; Lazar et al, 2000). In designing online communities, the systems must be usable, acting as an enabler for the people using the communities to fulfil their purpose within the bounds of laid out policies that guide members' interactions. Through listening to the views of members, online communities can continue to evolve and develop, making it easier for members to participate, and helping the community to fulfil its purpose.

Although the demarcation between online and offline activities is slowly starting to erode, it is still important to recognise that there are important differences between the two domains, including the lack of physical presence and non-verbal cues in online textual environments (Preece et al, 2003). However, the quality of users' experience can be ameliorated by creating visual representations as a means of supporting social interaction.

The problems relating to the lack of social presence in textual online communities has been noted by several researchers. A thorough knowledge of social interaction and the mediating effects of technology are required in order to develop a successful online community. Consequently, any solutions to the lack of co-presence must go beyond simply mimicking face-to-face interaction. The available technology must be used effectively in order to make it more powerful while ensuring universal usability (Preece, 2002). Avatars have been used to compensate to some extent, but screen real estate limitations pose problems in displaying more than a few individuals at any one time. Furthermore, avatars tend to suffer from a limited range of expressions that overlay a user's communications, and this can ultimately distort the user's expression or intent (Viegas & Donath, 1999). As a result, a variety of smaller, more abstract visualisations have since been developed in order to support social presence and give users a better perspective on community activity (Xiong & Donath, 1999; Erickson & Kellogg, 2000; Smith & Fiore, 2001; Mohamed et al, 2004a; Mohamed et al, 2004b). Issues relating to the use of visual cues to support online communities will be dealt with in more detail in the next chapter.

2.5 Further Design Principles

In addition to the primary elements of online communities that were laid out in the preceding section, other researchers including Kim (2000) and Kollock (1996) have identified further guiding principles for the design of successful and sustainable online communities. There is a large degree of overlap between these guiding principles and those outlined by Preece (2000).

Kim (1998; 2000) outlined nine design principles for fostering successful online communities, many of which extensively overlap with the elements outlined by Preece. Her work examines purpose, people, gathering places, evolving roles, leadership, rules and policies, planned events, rituals, and support of sub-groups as well as a variety of technologies for each strategy. These principles are augmented by three further strategies to support the social scaffolding of online communities:

- Design for growth
- Create and maintain feedback loops
- Empower members over time.

As with the elements outlined by Preece, Kim's principles are aimed at laying down a framework for fostering a sense of community and enhancing the users' experience.

Kollock (1996) adopted a sociological perspective to understand the key challenges behind building successful online communities. While recognising the technological and user interface challenges that exist, his design principles derive from work on cooperation and social dilemmas, and focus on fostering social interaction, cooperation, collective action and social order.

Once more there is level of congruence between his work and that of Kim and Preece, emphasising the requirement for ongoing interaction, individual identity

based on a person's prior behaviour, clearly-defined group boundaries, rules governing behaviour and effective moderation. All of these factors are important in fostering successful online communities, but they are by no means a panacea. Following these guiding elements and principles will undoubtedly help, and will go a long way towards helping build a successful and thriving online community. However it is still important to recognise that there are elements, such as the varying perspectives and motivations of users, which may be difficult to control and manage.

2.6 Measuring Success of Online Communities

Even if the correct structures are in place within an online community, there is still the matter of measuring the success of the community. All the people involved in online communities, from members to developers and leaders will all want to ensure that their community is a success since nobody wants a community they have been involved with to fail. However, these different stakeholders will each have different perspectives on how success can be measured (Andrews, 2000).

2.6.1 Stakeholders

Lazar & Preece (2002) identified four different groups of stakeholders with varying points of view on how success could be defined:

- Founders
- Leaders
- Moderators
- Members

Each of these different stakeholder groups will now be considered, examining in turn how the perspectives of each distinct group impacts on how they gauge the success of the community.

2.6.1.1 Community Founders

Community founders will have been involved with the community since its inception, and will have spent time organising the community, making sure it is easy to use, and starting to populate it with members. Even if they are no longer involved with the community, they will be interested in the continual population and use of the community, and will want to see that their work in establishing the community was not in vain. They may measure success as the continual use of the community. The community will not typically be deemed to be a success if nobody develops or manages resources, nobody posts messages and membership is low or moribund.

2.6.1.2 Community Leaders

Community leaders provide leadership within the community, welcome newcomers, and offer advice based on past experience. They tend to post frequently and take an active role in the community, making them well-known to the members. The leaders are not necessarily a unique and mutually exclusive group – they may also be founders or moderators, and are certainly members of the community. They may define success as whether their role is appreciated. A large number of posts in the community may also be seen as a success factor since their leadership helps to engage interaction and encourage discussion in the community.

2.6.1.3 Community Moderators

Community moderators are responsible for ensuring that all messages posted are appropriate and that all communication flows well. In an ideal world, there would be no requirement for moderators because conversations would flow well, all posts would be on-topic, and there would be no conflicts within the community. However, the moderator serves a key role in keeping discussions on-topic and active, rejecting or removing posts that are deemed off-topic, inappropriate or offensive. Community members value a strong moderator who stops aggressive and other inappropriate comments (Preece et al, 2004). Moderators may define success as having to reject a

minimum number of posts. If there are too many posts that need to be removed or rejected, this may indicate that members need to be reminded of the policy on posting. The success of moderators is dependent upon the views of members and if members are happy with the moderating, the moderator may feel that the community is successful and vice versa.

2.6.1.4 Community Members

Members will deem a community a success in a variety of ways. Some members may judge success on the availability of useful information, or on whether they meet people and develop personal relationships. Others may consider success to be whether they feel a sense of community or a sense of belonging (Roberts, 1998), while other members may gauge success based on the sense of support from other members going through similar experiences (Preece, 1998). But generally members will measure success on whether they are willing to remain part of the community over a period of time. Members will only remain a member of a community as long as it meets their needs better than alternative uses of their time (Levine & Moreland, 1994).

Conversation is the basic medium through which users derive benefit in online communities (Arguello et al, 2006). Whether users are explicitly seeking information or implicitly trying to direct conversations towards topics which interest them, members who try to start conversations are aiming to increase the likelihood that the group will provide benefits they value. It is the response from the community that satisfies the needs of the member making the initial post. In this way, the community's responsiveness to members' attempts to start a conversation provides a gauge of community success. If nobody responds, this can cause users to question their commitment to the community, and first time posters to a group are more likely to return if other members respond to their post (Joyce & Kraut, 2006).

2.6.2 Quantitative Measures

As discussed in the preceding sections, the various stakeholder groups have wide-ranging perspectives on what makes a community successful. Even within these groups, perspectives on success are equally varied. It can therefore be more straightforward to consider quantitative measures.

Shafer (1999) suggested a wide range of measures for gauging the success of online communities. These include: number of threads; number of posts; number of members; page views; time on site; and posting ratio. Although all of these measures provide interesting information, and are easy to calculate, none of these are necessarily effective measures of success. For example, the posting ratio does not measure the usefulness of the information posted, nor the use to which passive members of the group may put this information. Furthermore, it is not possible to say that a community is successful if it meets a benchmark such as 750 posts per week or has 2,000 members. An online community is not a certifiable exam where 80% is a pass mark and 79% is a fail (Lazar & Preece, 2002).

Despite the range of quantitative measures available, none of these are necessarily complete measures of success. No single quantifiable measure can reflect the success of an online community. As outlined previously, not all stakeholders determine success in the same fashion. Therefore, it is impossible to quantify from a set of metrics whether an online community is successful. Rather, it is preferable to also ascertain each stakeholder's group's perception of success in order to determine whether they deem the community is successful and fulfilling its purpose. Quantitative analysis will serve a key function in this process, allowing the examination of the underlying social structure, and providing a framework for understanding community interaction. Therefore, both quantitative and qualitative measures should be constituent parts of gauging the well-being, development and success of online communities.

2.7 Classification of Community Interactions

It is important to understand users' objectives as this will enable the design of systems aimed at supporting communities which are more sustainable in the long-term. There is a range of research focused on the main elements involved in designing online communities in order to make them more usable and successful (see sections 2.4 & 2.5). However, there is relatively little research on the type of interactions that take place within online communities in terms of trying to classify users' objectives.

A useful context to examine these objectives was provided by Maslow (1943; 1954) who established a hierarchy of needs as a means of clarifying how individuals are motivated to satisfy needs ranging from lower level survival needs to higher level self-fulfilment. Maslow's hierarchy of needs (see Figure 2.1) is based on a progression hypothesis, with individuals being motivated to satisfy lower level 'deficit needs' before focussing on higher level 'being needs' (Bishop, 2007).

Figure 2.1: Maslow's Hierarchy of Needs



Source: Kim, 2000, p.8.

Kim (2000) has adapted Maslow's hierarchy of needs for use in building and developing online communities (see Table 2.1).

Table 2.1: Maslow's Hierarchy of Needs Within an Online Community

NEED	OFFLINE	ONLINE
<i>Physiological</i>	Food, clothing, shelter, health	System access; the ability to maintain one's identity and participate in an online community
<i>Security and Safety</i>	Protection from crimes and war; the sense of living in a fair and just society	Protection from hacking and personal attacks; the sense of having a "level playing field"
<i>Social</i>	The ability to give and receive love; the feeling of belonging to a group	Belonging to the community as a whole, and to subgroups within the community
<i>Self-esteem</i>	Self-respect; the ability to earn the respect of others, and contribute to society	The ability to contribute to the community, and be recognised for those contributions
<i>Self-actualisation</i>	The ability to develop skills and fulfil one's potential	The ability to take on a community role that develops skills and opens up new opportunities

Source: Kim, 2000, p.9.

Adapting Maslow's hierarchy of needs for use in an online environment, helps in identifying whether the needs and the purpose of the online community are being met. As the needs of community members are satisfied, the community should thrive and develop, resulting in a more successful community. As part of this progression, self-defined sub-groups can form an important part of growing large-scale communities. However, it is important to note that it is better to launch sub-groups later in the evolution of the community once the culture has become established and members have had the opportunity to communicate their needs and desires (Kim, 2000). Once the community has become established and members have begun to identify with the community, member-created sub-groups can be allowed to develop as a means of providing the intimacy that was felt by members when the community was in its infancy (Preece, 2000).

However, whilst Kim's work provides a structure for understanding the motivations of members of online communities, there is evidence to suggest that individuals do not necessarily need to satisfy all lower level needs in order to address higher level needs. For example, there are cases of Internet addicts who go without sleep and food in order to fulfil what they perceive as being higher level online needs (Griffiths, 2005). It is also not necessarily the case that users automatically progress through the stages of the hierarchy of needs. Some online community members fail to progress from being passive observers towards making contributions, despite fully satisfying lower level needs. Despite such flaws, the hierarchy of needs does provide a broad base for trying to classify the motivations behind the various user interactions that take place in an online community.

As has already been discussed, there are various types of online community. Irrespective of the different purposes, functions or domains of these online communities, there are some high-level objectives that are common across the majority of communities. These include the exchange of information, socializing and meeting people, and discussing ideas. These high-level objectives can then be broken down into some lower-level objectives, such as posting messages, conducting or participating in chats, searching for information, and responding to messages (Preece, 2000). Warms et al (2000b) suggested a further range of elements that constitute a user's investment in online communities, including the time spent understanding a community and finding relevant discussions.

The various elements outlined by Preece (2000) and Warms et al (2000b) have been combined to develop the content of a new taxonomy of users' interactions and objectives in online communities (see Table 2.2). This new taxonomy is useful in helping to conceptualise the spectrum of different activities that online community users can be involved with. As users meet lower-level objectives, they may seek to achieve more long-term goals that see them become more active participants and valued members of the community.

Table 2.2: Taxonomy of User Objectives

Timescale	Interaction Objective	Description
Short-term	Understand the community	Get an overview of the basic offerings and content of the community
	Find relevant discussions and information of interest	Look for topics or resources of interest. Search for discussions or other member-created content to find information of interest
	Learn about community members	Discover more about other members through their profiles and/or their contributions to discussions. Find other members with similar interests
Medium-term	Contribute to the community	Learn the rules for contributing. Develop and contribute questions, information, and ideas
	Receive a response from the community	Wait for responses to initial contribution. Check back for updates
Long-term	Gain satisfaction	Benefit from being an active participant in the community
	Gain a sense of belonging	Meet and interact with other members with similar interests
	Gain recognition	Make enough contributions over an extended period of time in order to gain positive feedback and earn the respect of other members and peers
	Be engaged	Become a regular participant in the community over a period of time

When a user first joins an online community, they frequently attempt to get a quick overview of the community's content (Warms et al, 2000b). In the short-term they often browse the web pages and message boards in order to find out whether the community meets their needs and will be of interest to them. During this information-discovery phase a user tends to take a passive role in the community, searching for resources or topics of interest, and looking for other users with similar interests (Preece, 2000). They typically try to find out who the core members of the community are, looking at member profiles and browsing through topics on the bulletin board in order to discover more information about other members. As part of this process, they may also attempt to determine the authority of users' posts, gauging whether the messages posted are informative or useful.

Having monitored the community and found information of interest, users may be motivated to contribute towards the community in the medium-term, taking part in the bulletin board or posting information. There is no requirement for users to progress towards making contributions, but they are more likely to post messages of their own if they have found information or topics of interest during the information-discovery phase (Preece, 2000; Preece et al, 2004). After making any initial contributions, users will often wait for responses to their initial contribution, checking the community for any updates on a regular basis.

If a user receives responses to their posts, this should engender a sense of satisfaction on their part as they actively participate in the community and start to interact with other members (Nonnecke & Preece, 2000; Preece, 2000; Mager & Karlenzig, 2001). In the long-term, this will generate a sense of belonging as they begin to engage with fellow members who have similar interests. Continued contributions over a longer period of time should mean that a user will become recognised as being a more active participant within the community, gaining positive feedback and earning the respect of fellow members (Girgensohn & Lee, 2002; Joyce & Kraut, 2006). As users become regular participants in the community over an extended period of time they will become engaged with the community, and this should benefit the community as a whole, as further members become active participants.

Under this new taxonomy, users will have typically met lower level objectives before progressing towards medium and long-term objectives. For example, they are likely to have read some postings before making any contributions. Similarly, it is only through contributing that they can start to interact with other members and find users with similar interests, gaining recognition within the community if this continues over an extended period of time (Ginsburg & Weisband, 2002; Culnan, 2006).

As already discussed, people may serve different roles in different online communities and as such, a user may play an active role in one community while being more passive in a different community. Therefore, a user's level of activity in any community may be governed by the varying structures of different groups, and this can direct and constrain how people act in these groups (Golder & Donath, 2004).

Similarly, a user's information gathering phase may differ throughout their period of membership of an individual online community. While a user may be recognised as a long-term core member of a community, contributing to discussions on a regular basis, they will still seek to satisfy short-term objectives before making contributions, albeit that this time spent in the information-discovery phase may be more condensed than it would be for a new member. All members will typically seek out topics or resources of interest before contributing, but the time spent on such activities will tend to be shorter for users who are more familiar with the community due to their longer period of membership and more frequent visits to the community.

The frequency of users' visits to the community may also have an impact on the length of time spent in the information-discovery phase with less frequent visits resulting in more time spent gathering information. For example, if a user is absent from a community for an extended period of time, they are more likely to spend an extended period of time gathering information upon their return before making any contributions to the community.

It is also important to recognise that not all users will wish to contribute and some users will be content to remain passive members of the community (Soroka & Rafaeli, 2006). However, if there are not enough active members, the community is ultimately unsustainable (Terveen & McDonald, 2005). When there is a dearth of members making contributions with an online community, this may ultimately lead to the death of the community as it struggles to attract and retain members. Although some communities have a sufficient or excessive volume of posts, there are numerous examples of message boards which have become moribund; participation has dropped to zero and there are many topics but no responses. Butler (1999) found that 50% of social, hobby and work mailing lists had no traffic at all over a four-month period.

Structuring user objectives into a taxonomy provides a framework for investigating techniques for encouraging member participation within online communities. The next section considers the issues relating to motivating users to progress from being passive members, content to satisfy short-term objectives, towards being more active participants, aiming to satisfy medium and long-term objectives.

2.8 Challenges in Encouraging Contributions

The key challenges for any online community are encouraging quality contributions from members, and getting users to return and contribute on a regular basis. Repeated social interactions increase familiarity, strengthen relationships and support a sense of community (Girgensohn & Lee, 2002).

"Communication is key to almost everything that humans do" (Schuler, 1997). Communication is the core of online communities, with collective action, exchanges of social support, and sense of community rooted in the conversations that members of the community have with each other (Ginsburg & Weisband, 2002; Culnan, 2006). Without contributions and exchanges between users, there would be no sense of community. Therefore, creating thriving gathering places that encourage conversation is at the heart of building and sustaining an online community.

However, creating gathering places alone is not enough - they need to be organised and integrated into the community. As discussed in the previous section, there are numerous examples of message boards with few contributions.

While synchronous communication in the form of chat rooms can be used, these are a frequently misused community technology (Steuer, 1998). Nothing discourages users more than an empty chat room, or an interactive event that has very little or zero interaction between users. Synchronous chat requires all participants to be present at the same time, and communications usually take the form of shorter comments. However, when arranging real-time chats, there can be problems of scheduling suitable times that are convenient for most members, especially in geographically dispersed communities that are separated by a range of time zones. There are also concerns related to synchronous chat with respect to users 'talking over' one another as several users start typing messages at the same time (Baker-Eveleth et al, 2005). Multiple messages may also pop up at the same time, thus clouding the meaning of a post due to the temporal disordering of messages. In busy chat rooms, there is a high communication load and this means that fewer active users can be sustained due to information overload. This can cause some members to either filter and ignore information, or even leave the community completely (Franz, 1999; Jones & Rafaeli, 1999; Nonnecke & Preece, 2000). Chat rooms also suffer from a lack of persistence, with content evaporating as soon as it scrolls out of each user's history buffer (Smith et al, 2000). This lack of persistence means that chat spaces do not accrete a social history in the same way that asynchronous forms of communication such as bulletin boards do. It is because of these problems that the main communication medium within online communities tends to be asynchronous in nature.

A major benefit of using asynchronous forms of communication such as mailing lists and bulletin boards is that they are not constrained by chronology or distance, and are more suited to geographically-dispersed online communities. Community mailing lists can facilitate conference-style interaction between members. However, mailing lists do not create the same sense of gathering in a location with fellow community

members that conference-style interaction can provide (Steuer, 1998). Therefore, conference-style mediums such as bulletin boards play a crucial role in community development. Bulletin boards can enhance a sense of belonging and community by providing a focal meeting place, just as a real world community may meet in the local town hall.

The asynchronous aspect of online discussion allows community members to check bulletin boards at their discretion and also enables them to be more active and reflective in their comments (Cothrel & Williams, 2000). The use of bulletin boards also encourages multiple conversations within a given topic, allowing the community to sub-divide into specific interest groups and as threads develop, people can choose to focus only on those threads of interest to them (Kim, 2000). In addition to supporting the community's sense of context and history, bulletin boards can also act as a platform for either asking or answering any questions that may not be covered by the FAQ⁴. However, it is important to bear in mind that having a wide range of forums when they are not required can be an impediment to community development. A range of empty forums will only serve to discourage users from participating, and sub-groups should only be formed when a critical mass has been achieved.

The core members of an online community are its most frequent and loyal posters, and they are the critical mass of the community. There is a power law relationship between the core group and message distribution, indicating that a very small group contributes significantly more content than all other members (Mockus et al, 2002). The core members often perform a large proportion of community building and maintenance work including reading and writing messages, and moderating the site (Butler et al, 2002). There are also familiarity and reputation effects associated with being a core member of the community. Posts from new members tend not to evoke as many replies as posts from users who have been members for a long time (Bonvillain, 1993; Arguello et al, 2006). This may be due to the fact that repeated

⁴ FAQ is an abbreviation of 'Frequently Asked Questions'. It refers to listed questions and answers, and addresses the most common questions that any newcomer to the online community may have. The FAQ can evolve over time, incorporating new details as the community evolves.

exposure to core members causes other members of the community to be more familiar with them, and therefore more likely to respond to their messages.

While the core members serve an invaluable function within an online community, they are usually in the minority. The majority of members of online communities are more passive in nature, content to remain in the information-discovery phase, observing what is going on and lurking in the background. Some of these users are reticent to become involved in discussion and are content to socially 'loaf'; waiting for others to answer any questions that may be raised rather than becoming involved. One contributing factor in a user's decision to take a more passive role in a community may be the cost of participating in terms of the investment of time and energy required. Therefore, the challenge lies in motivating these users by reducing the barriers to participation that may currently be preventing users from progressing towards becoming more active participants and satisfying more medium and long-term objectives. One possible way of reducing these barriers to participation is through the provision of simple visualisations that augment the existing community, enabling users to quickly get an overview of current activity. These issues will be covered in more detail in the sections which follow.

2.8.1 Case Study: STORM

As a sample case study of the problems faced in trying to encourage contributions within an online community, the example of STORM (Ferguson et al, 2002) is considered in this section. The Scottish Teachers Online Resource Modules (STORM) was launched in May 2000 as the result of a joint venture between the University of Strathclyde and the Scottish Executive Education Department (SEED). STORM was aimed at providing support for teachers of computing courses (Computing and Information Systems) at Scottish schools. The University of Strathclyde developed the content of the STORM, and the Department of Computer Science at the University of Strathclyde worked closely with the Department of Business and Computer Education and practising teachers to develop and support the material on the STORM website. The material on the site was not designed for direct

classroom use with students, but rather as a resource that could be used by teachers to aid their professional development. The purpose of the STORM material was to provide teachers with the necessary additional skills and confidence to enhance and enable their role in the classroom. Along with the online course material, STORM provided several communication tools on the site that were aimed at engaging debate and discussion about the subject matter of the material. There were both synchronous and asynchronous tools in the form of chat rooms and bulletin boards provided under the umbrella of a Web/CT framework.

Only registered users were able to log into the main area of STORM, with registration limited to members of staff in Scottish schools and colleges involved in teaching national qualifications in computing and related subjects. Despite there being a large number of teachers who registered for the site, only 65.32% of registered users ever actually visited the site, and the penetration ratio, measuring the number of unique visitors against total active members, peaked at only 49.11% (Mohamed, 2001).

STORM had a total of six chat rooms and five bulletin boards which were intended to be used to discuss the STORM content. However, both areas were severely underutilised, with a paucity of traffic to any of these sections of the site. Prior to the launch of STORM, there was already a thriving online community of teachers who were communicating with each other via discussion lists on Yahoo! Groups, and this meant that many users did not use the STORM facilities due to the fact that they were already using the existing Yahoo! Groups. Throughout the first year since its inception, the number of posts to the Yahoo! Groups outstripped posts to the STORM bulletin boards by 98:1 (Mohamed, 2001).

STORM was fully publicised via postings to the Yahoo! Groups, as well as presentations at various teacher seminars. Despite this, the site tended to be used more as an information repository by users, while they continued to use the existing Yahoo! Groups as their main communication medium even though STORM had a more extensive range of bulletin boards and chat rooms.

There was a clear problem in attracting users to STORM. Running both STORM and the Yahoo! Groups in parallel had a detrimental effect on STORM, resulting in lower site traffic and moribund bulletin boards. With hindsight, it would have been advantageous to launch STORM with only one bulletin board as the wide range of empty chat rooms and bulletin boards may have ultimately discouraged members from using them. Further effort on the part of the moderators in terms of starting threads may also have resulted in an increase in contributions from members. However, the main factor in STORM's lack of success was the fact that it attempted to provide a wide range of communication forums when this function was already being provided by the Yahoo! Groups.

As discussed earlier in this chapter, for an online community to be sustainable and generate social interaction, the collective purpose of the community must be consistent with the goals of individual members. However, this was not the case for STORM. The purpose of STORM, as envisioned by its founders, was not congruous with the views of the users; the users saw STORM as more of an information repository, and were content to keep using the established Yahoo! Groups to communicate with each other.

STORM was a success in terms of providing information to the members, which they used for their continuing professional development. However, the site failed to fulfil its purpose in terms of creating a sense of community. Had the existing Yahoo! Mailing lists been integrated within STORM, this would undoubtedly have helped encourage more people to both visit STORM and use its bulletin boards. Users would have been more likely to return to the site on a regular basis, which would have increased the likelihood of them making contributions on the bulletin boards. These repeated social interactions would have increased familiarity, strengthened relationships and helped engender a sense of community.

STORM provides evidence that creating gathering places alone is not enough to ensure a successful online community - they need to be organised and integrated into

the community. The key challenges for any online community are encouraging quality contributions from members, and getting users to return and contribute on a regular basis. Ultimately, STORM failed in this respect.

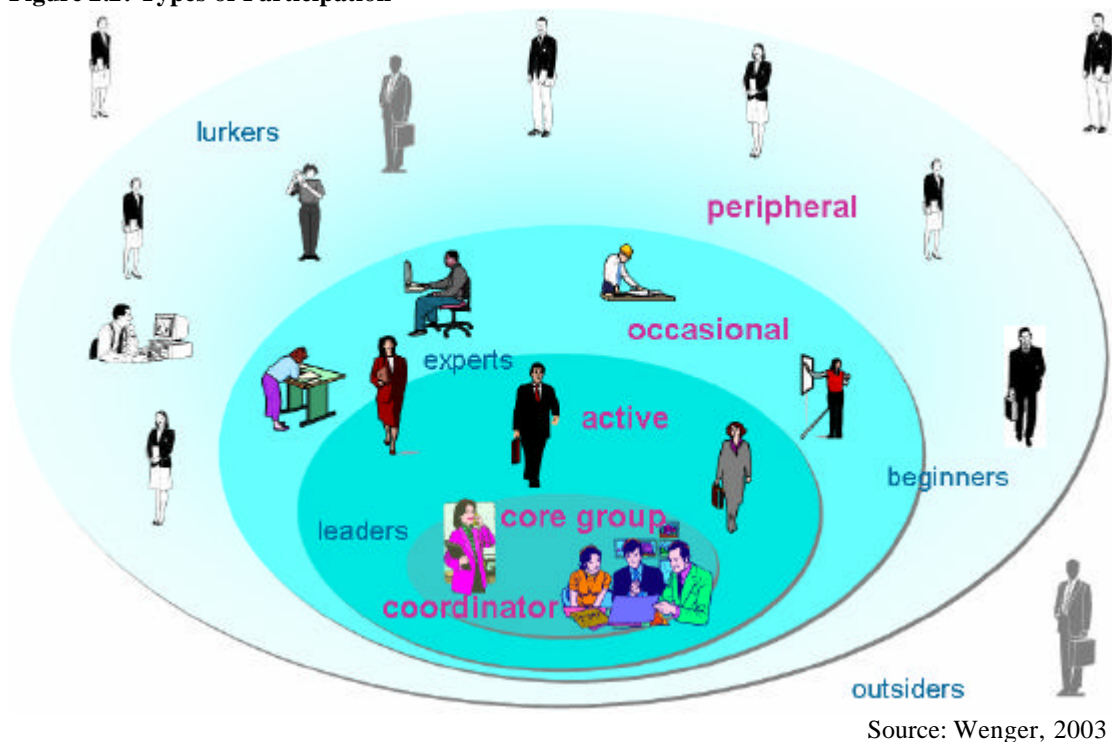
2.8.2 Lurking

Like STORM, many other online communities face challenges in encouraging users to be more active participants. Warms et al (2000a) found that, in the sites they examined, readers outnumbered posters by 10 to 1 or more. This suggests that more than 90% of the total community population who regularly visit a community fail to post, choosing instead to use the information they gain without taking an active role (Katz, 1998; Mason, 1999). MoviLens⁵, a movie recommendation community, is another example of a community that suffered from a lack of discussion, with only 2% of members contributing posts in their discussion forums (Harper et al, 2007). However, it is difficult to gauge the success of a community by examining the posting ratio in isolation. An understanding of the true value of information lies in examining what it is used for.

The level of participation by members within communities varies between individuals (see Figure 2.2). Some take an active role in the community, contributing to discussions, or providing fellow members with assistance. Others merely read what others have posted without personally taking an active role, becoming a persistent but silent audience (Soroka & Rafaeli, 2006). An individual may also play both active and passive roles over the course of their membership within the community, and may also play both active and passive roles across different communities. By being part of social groups, people occupy different positions in the structures of different groups, and this governs how people act in these groups, constraining them from saying and doing things in some circumstances (Golder & Donath, 2004).

⁵ <http://movielens.org>

Figure 2.2: Types of Participation



Typically, visitors first ‘lurk’ at the periphery of the information space (Wenger, 2003), reading posts without actually participating, getting a sense of what is acceptable in the community, and judging the ambience; later some may post messages, becoming active participants in the community, bringing in new knowledge, perspectives and energy (Nonnecke & Preece, 2000; Mager & Karlenzig, 2001). Even established community participants adopt this strategy when joining new communities, because each community has its own ‘netiquette’⁶, standards and ways of behaving (Preece, 2004). In fact, the reaction of the community to members making their first post can have an impact on other lurkers.

Lurking rates are significantly higher in communities that do not respond positively to new posters, suggesting that special attention to acknowledge and respond to new members is important (Preece et al, 2004). If there is a high degree of ‘flaming’⁷ associated with newcomers, this can impact the attitude of other lurkers. Soroka et al

⁶ Netiquette refers to online etiquette, and the norms of acceptable behaviour when communicating online.

⁷ Flaming refers to a verbal attack on someone in an online forum, often using hostile or derogatory language.

(2003) found a correlation between a positive first posting experience and subsequent active participation in the community. Furthermore, a user does not need to actually post in order to see how other newcomers are welcomed. If the general atmosphere in the community is bad, the reaction to newcomers is non-welcoming or an attitude to user's subjects of interest is negative, people may elect to stay silent or even leave the community completely.

Although the term lurker is sometimes seen as pejorative, it is not necessarily the case that being a lurker is a bad thing. Many lurkers are just as interested in the topic of conversation as more active members, and are merely trying to learn from others. Lurkers may even be new to the topic area being discussed and may not have much to add to the conversation. Perhaps more importantly, although lurkers may not be contributing to the conversations, these passive members may be actively using the information they gain (Warms et al, 2000a). As such, lurking may simply be seen as a different communication role. In any case, it would be unreasonable to expect users to post frequent messages when they may not have anything useful to say.

Despite taking a more passive role, lurkers also feel a 'sense of community' – they feel that they belong to the community through watching other people talk and by becoming familiar with the content and style of the community (Beaudouin & Velkovska, 1999; Preece et al, 2004; Soroka & Rafaeli, 2006). However, Preece et al (2004) did find that those members who posted messages within online communities were more satisfied with their community experience than those who did not post, and had a greater sense of belonging to a community than lurkers; satisfying medium and long-term objectives of posting messages helps to engender a sense of community from active participants.

For passive members, the experience of obtaining valuable information builds a sense of indebtedness that will undoubtedly be expressed in contributions when that person has something of value to share. Therefore the greater the level of participation from a wider range of participants taking place in the community over

an extended period of time, the greater the value created for the members and community administrators.

In a text-based environment, if a user writes nothing, they effectively cease to exist. Consequently, if a lurker does not exist in a way that can be perceived or responded to by others online, there is no way that they can be an active part of the community (Riva, 2001). However, the presence of lurkers can be easily shown by displaying counts of the number of times that each thread is read, and by showing a list of users online on the front page of each forum. This information may actually go some way towards helping increase participation by motivating other posters; awareness indicators that show who is currently online, and what they are doing, may help engender a sense of community.

Communities with low traffic would undoubtedly benefit from the presence of additional posters who contribute content, and there would even be benefits from having additional lurkers, whose visible presence could help encourage contributions from other users (Preece et al, 2004). However, despite the fact that there is no requirement for everyone to contribute in order for an online community to be successful, groups with large proportions of lurkers over extended periods of time will suffer from a paucity of new contributions and this will ultimately lead to the death of the community as it struggles to attract and retain members. If there are too few contributors in an online community, there will not be sufficient interaction to sustain and maintain the interests of members. A critical mass of content and participation is required in order to encourage existing members to continue to interact, as well as attract contributions from new or previously passive members (Preece, 2000). As more members post messages on a regular basis, other members will become more familiar with them and this will ultimately help increase posts from other members, and this will in turn engender a sense of community. Whittaker et al (1998) found that familiarity of users had a positive influence on interactivity, providing evidence that increased participation by users should help towards a critical mass. This critical mass will be achieved when the community is sufficiently

large enough to sustain the needs of both its contributors and its lurkers (Tedjamulia et al, 2005).

2.8.3 Social Loafing

Allied to the issue of lurking, Kollock & Smith, (1996) argue that there is a degree of ‘social loafing’ present in online communities, just as there is ‘free-riding’ in society in general. In society, there is a tendency for people to consume more than their fair share of common pool resources, while contributing less than the optimal amount towards public goods (Ledyard, 1995). Contributions to an online community may be seen as public goods since members can freely consume information without contributing or diminishing the consumption of others (Wasko & Faraj, 2000). Under the phenomenon of social loafing, people in a group exert less effort on a collective task than they would when completing a comparable task on an individual basis. For example, a question may be asked by a newcomer and while a lurker may be more inclined to provide the answer in a one-on-one situation, they may be less inclined to provide the answer in a group situation because they believe that the answer will be provided by another group member. Bringing people together in a group does not guarantee participation. There is no assurance that people will post messages or answer questions, and if there is no participation, the community will be stillborn (Terveen & McDonald, 2005).

Karau and Williams (1993) developed a collective effort model to explain social loafing, and posit that people work hard when they believe that their effort will help them achieve outcomes that they value. Under this model, being part of a group impacts on how hard people work because it can change their perception of the importance of their contribution to achieving a specific level of performance, the likelihood of reaching the goal, and the value they place on the outcomes gained by their efforts (Harkins & Petty, 1982; Kerr, 1983; Kerr & Bruun, 1983). If an online community is to be sustainable in the long-term, there needs to be some degree of reciprocity, with users giving to the community as well as taking from it. To this end, there must be congruence between the goals of the community and the motivations of

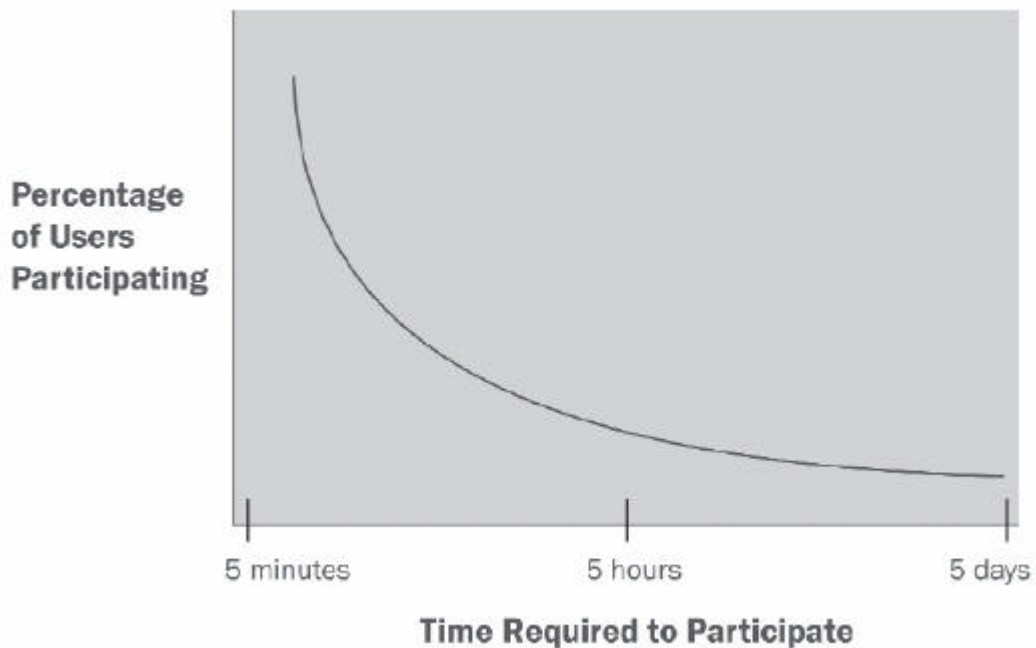
individual users in order to encourage contributions. People interact with, and provide help to, people they know, people they like, people who are similar, and people who have helped them previously (Constant et al, 1997). Allied to this, theories of pro-social motivation suggest that people provide help to strangers even when this help is personally costly. This is because helping others can help increase self-esteem, personal identification within the community, feelings of commitment, and also help to promote generalised reciprocity (Constant et al, 1997).

Describing lurkers as free-riders classifies them as using the resources of the community, without actually giving anything back to the group. However, given that the vast majority of online community members are lurkers, this raises the question of how online communities survive and prosper despite this widespread free-riding. Rather, lurking is both acceptable and beneficial in online communities (Nonnecke & Preece, 2000) and, as discussed in the previous section, public posting is only one way in which a community can benefit from its members.

2.8.4 Time Elasticity

One causal factor in the reluctance of users to make contributions within the community may be the cost of making a contribution in terms of the time taken to participate in the community. The concept of price elasticity in economics refers to the principle that the demand for a product will change in relation to the price of the product. Generally, as the price of a product rises, the demand for the product drops as consumers start substituting other goods. According to Warm's et al (2000b), a similar principle of time elasticity applies when examining the investment that participants make in online communities. As the time required to participate in the community increases, the number of users who will participate decreases. When the cost of participating (in terms of time) goes down, the level of participation goes up (see Figure 2.3), as more users start to satisfy more medium and long-term objectives aimed at contributing towards discussions within the community. This effect becomes exponential as the investment of time required to participate falls to a point where the community is within reach of every potential participant.

Figure 2.3: Time Elasticity of Participation in Online Communities



Source: Warms et al, 2000b, p3

The challenge lies in reducing the barriers to entry that are currently preventing users from becoming active participants in online communities. As the time required to participate falls, a higher percentage of users should start contributing to the discussions within the community. One possible way of doing this would be to reduce the investment of time and effort required from users before they feel comfortable in participating. This can be done by reducing the amount of time that users spend in the information-discovery phase as they seek to satisfy short-term objectives and gather information about the community and its members.

2.8.5 Visual Representations

Instruments that reduce the time between a user joining a community and then becoming an active participant have the potential to act as a driver towards more successful, thriving online communities, thus engendering a greater sense of community amongst users. Making users' contributions more identifiable should also help towards this objective of thriving communities, and one possible avenue

towards achieving this goal of engaging members and encouraging contributions would be to use simple visual representations within an online community setting. Promoting the visibility of users and their activities can encourage people to become more active and can prolong participation (Girgensohn & Lee, 2002).

Preece et al (2004) found that people lurk while getting to know the community. This information-discovery phase can be especially problematic in communities where there are vast numbers of messages as newcomers become somewhat discombobulated and spend time getting an overview of discussions while navigating through the community. Large numbers of participants and messages can make it difficult for new users to comprehend the interaction context of the community, track user participation and understand the social connections within the community (Zhang & Lee, 2002). The problems caused by there being too many messages to sort through can be alleviated by the provision of visual interfaces to the community. Users can then quickly get a picture of the previous interactions within the community, and can immediately identify the core members and central topics of conversation.

Research has shown that visualising participants and the structure of discussions can help to encourage new participants and encourage contributions within online communities (Takahashi et al, 1999; Smith & Fiore, 2001). Visual representations can show information flow and inter-relationships more easily than expository text (Larkin & Simon, 1987), are intuitive for perception and thought, and are considered relatively easy to process and didactically effective (Carswell & Richardson, 2002).

There are several ways in which the provision of visualisations may be useful, including showing the level of activity within the community over different time periods, and showing which members tend to answer particular types of questions (Erickson & Kellogg, 2000; Donath, 2002; Erickson et al, 2002). Visualisations could also be utilised to help users search for fellow members with similar interests, acting as a driver for increased social activity within the community. Visualisations could be used in a wide range of ways as a means of supporting online communities,

and these potential areas of application will be covered in more detail in the next chapter.

2.9 Summary

The growing number of people using the Internet has meant that increasing numbers of people are participating in online communities. This chapter has reviewed the literature in this area. It has shown that online communities relate to people interacting socially around a common interest or purpose, following rules that guide their interactions and using systems to facilitate a sense of togetherness.

The framework for online communities can be implemented fairly quickly, but creating self-sustaining communities is much more difficult. In order for a community to be successful and allowed to develop, it must meet the requirements of its members. The members must have a shared passion and be willing to openly share information. Online communities grow and thrive when members are able to fulfil their purpose and accomplish those goals that require other members to participate.

Given that there is relatively little research into the type of interactions that take place within online communities in terms of trying to classify users' objectives, a taxonomy of community interactions was proposed. The structure of the taxonomy shows that users would have to satisfy short-term information-seeking objectives before being able to progress towards becoming more active participants. Members of online communities tend to take a more passive role at first as they discover information about the community, before possibly becoming more active participants in the community through contributing and interacting with other members.

However, there are numerous examples of online communities which ultimately fail due to lack of involvement from users who are content to lurk, playing a passive role in the community. Therefore, a key challenge in creating sustainable online communities lies in encouraging more members to progress from passive

involvement towards becoming active participants, making more contributions over an extended period of time. Given the evidence that the number of active participants in a community decreases as the time required to participate increases, the aim must be to reduce the investment of time and effort required from users before they feel comfortable in becoming active participants.

Support systems are needed in order to facilitate the formation of viable communities. Such support systems should engage members in ways that will prompt contributions from them and engender a sense of community. Visualisations that augment online communities have the potential to be used in this fashion as a means of supporting new members and encouraging contributions. The next chapter reviews the various ways in which visualisations could be used to support online communities as a driver towards increasing social interaction and activity.

Chapter 3 Visualisations

3.1 Introduction

The previous chapter highlighted the growing evidence that many online communities fail to fulfil their purpose due to lack of involvement by members. Further, while many online communities are supported through the use of communication technology such as bulletin boards, there is also evidence that the provision of these facilities alone is insufficient to engender a sense of community; there are many examples of online communities offering these facilities with little or no participation from users (Butler, 1999; Kim, 2000; Mohamed et al, 2002). Successful online communities need to be organised and adopted by the community; members must have a shared purpose and be willing to openly share information. They grow and thrive when members are able to fulfil that purpose and accomplish those goals that require other members to participate in the community (Ferguson et al, 2002).

A key challenge lies in encouraging further contributions from members, and online communities need to provide environments that facilitate social interactions. Research has shown that visualising participants and the structure of discussions can help to encourage new participants, contributions and social interactions within online communities (Takahashi et al, 1999; Smith & Fiore, 2001). This chapter reviews previous work into the use of visualisations within online communities, with the aim of using visualisations as a driver towards increasing levels of communication within online communities.

3.2 Text-Based Communities

A major problem faced in trying to sustain online communities is that of withdrawal or attrition (Haythornthwaite et al, 2000; Johnson, 2001). A contributing factor is the prevalence of text-based representations which tend to suggest uniformity and ennui rather than the lively social scene that may actually be present (Minar & Donath,

1999; Dieberger et al, 2000; Donath, 2002). Online communities often look and feel abstract and informational rather than inviting for social interaction (Lee et al, 2004). The concept of community is normally associated with interaction and shared co-presence, whereas the typical contact between a user and a website is on the whole a solitary experience with limited visual clues indicating the presence of other participants and their activity (Wexelblat, 1999; Dieberger et al, 2000; Svensson et al, 2001). Without visibility of who is around, it is difficult for social interaction to occur (Jung & Lee, 2000).

Furthermore, text-based representations tend to be unclear and are often impenetrable (Boyd et al, 2002; Fiore et al, 2002), offering limited information about the social context of the interactions they host. There is an absence of social cues indicating the size and nature of groups, making information-discovery and navigation an increasing challenge as the size and scope of spaces expands (Smith, 2002). There is little sense of the presence of other people and extensive user participation is often required in order to gain a holistic view of the interaction environment and context. Given the widespread use of text-based online communities and bulletin boards, which make it difficult to contextualise the interactions that are taking place, a user's information-discovery phase is often longer; prolonged membership is often required in order to find topics of interest, and identify the key or leading members within the community (Hattori et al, 1999). While textual representations do contain cues about the conversation structure, the relationship among the participants and their roles in the discussion, these cues are often hidden in vast amounts of text (Donath, 2006).

Information overload is a key problem most users face in online communities (Zhang & Lee, 2002), and the temporal development of conversations can sometimes be difficult to identify. This makes it time-consuming for users to browse through the large number of threads in order to find topics of interest. Conversation archives provide a record of the history of an online community, and having a way to quickly and easily comprehend the structure and content of this material can make it far more useful, both as a tool for newcomers to get an understanding of the social environment, and also for long-term members to grasp the nuances of evolving

relationships. Many online communities enable threads to be sorted by time, and hot topics of interest are usually made 'sticky' at the top of forums. However, users still frequently need to browse through different pages to find topics of interest. Therefore, there is a requirement for good facilitation techniques to support online communication technology (Smith & Fiore, 2001), enabling users to easily find out information such as: Who participated? Who has been active or influential? What was talked about? Were the discussions lively or desultory? (Donath, 2006)

In general web browsing, non-knowledgeable users of a site tend to rely more heavily upon navigation aids than knowledgeable users, and research has shown that the use of site maps is most useful when gaining familiarity with new material (Danielson, 2002). One of the primary differences between the knowledge of experienced and inexperienced users in a subject domain is that of familiarity with, and conceptual structure of, the material. The provision of contextual information can quickly give non-knowledgeable users a reflection of the conceptual structure of material. In a similar way, the provision of aids to conceptualise the online community context should help users in their information-discovery phase.

Recognising, identifying and attributing participation has been shown to be valuable for encouraging participation (Constant et al, 1997; Kollock, 1999; Kim, 2000). Instruments that encourage greater contribution, raising levels of communication and feelings of kinship, should enable interaction and remove barriers that lead to lack of involvement and community stagnation. One such technique is the use of visualisations to augment and enhance online communities. Information visualisation focuses on creating rich visual interfaces to help users understand and navigate through complex information space (Eick, 2001). Information visualisation has traditionally been used in the analysis of large amounts of commercial, financial and scientific data. Such approaches have also been adapted to help users interactively filter information for everyday tasks such as selecting movies (Ahlberg & Shneiderman, 1994; Card et al, 1999)

3.3 Power of Visualisations

Since the introduction of data graphics in the late 18th century, visual representations of abstract information have proven valuable in demystifying data and revealing otherwise hidden patterns (Tufte, 1983). Visualisation techniques create visual representations or graphical models of datasets and usually support direct interaction in addition to allowing users to explore and understand the represented information (Dix & Ellis, 1998; Card et al, 1999). They augment human cognition by leveraging human visual capabilities to make sense of abstract information, providing techniques for developing insight and understanding (Card et al, 1999; Heer et al, 2005). Visualisations can render large volumes of information in a limited space, enabling exploration and comprehension (Zhang & Lee, 2002); a picture is often said to be worth a thousand words. A visualisation can result in a high degree of additional insight into the data it represents, and the provision of interactivity can considerably increase the effectiveness of the visualisation (Bertin, 1983; Spence, 2001). As such, any information that is visualised must be timely so that it helps users complete the task that they are currently undertaking.

Humans have remarkable perceptual abilities that are greatly underutilised in current text-based online community designs; users can scan, recognise and recall visual cues rapidly, and can detect changes in size, colour, shape, movement or texture (Shneiderman, 1996). Furthermore, people think spatially (Lakoff & Johnston, 1980) and the use of graphical representations can attract viewers and provoke curiosity (Tufte, 1983). Taking a spatially oriented approach through the provision of visualisations to augment online communities will take advantage of this human trait (Boyd et al, 2002), using intuition and perception to amplify cognition and reduce the amount of time spent in the information-discovery phase. Visualisations can reduce the time spent searching for data by filtering (Wexelblat & Maes, 1999), grouping or visually relating information, and they can also compact information into a small space (Card et al, 1999). By presenting information visually and allowing dynamic user control through direct manipulation principles, it is possible to traverse large information spaces and facilitate comprehension of the underlying data with reduced

anxiety (Shneiderman, 1992; Robertson et al, 1993; Ahlberg & Shneiderman, 1994). The aim is to utilise visualisations to enrich the user's experience within an online community, leading to benefits such as reinforcing the immediacy of the shared experience through the use of visual cues and indicators, thus enabling online community participation and sustainability.

Unlike information visualisation, which has the goal of helping users digest information more effectively, or data visualisation which has the goal of helping users analyse and identify trends in data, visualisation of social activity in an online community aims to create awareness and catalyse social interactions amongst users (Lee et al, 2001), encouraging users to explore and understand the social environment of the online community (Donath et al, 2001). As such, the use of visualisations can prove useful in helping members understand and contextualise activity within online communities. Visualisations present information from which the presence, activities, and other characteristics of members may be inferred, and, by extension, provide the basis for making inferences about the activities and characteristics of the group as a whole (Smith & Fiore, 2001; Erickson, 2003).

Visual representation of social phenomena is important in the design of successful software to support online communities (Donath, 2002). Graphical interfaces in the form of visualisations can provide a way to see information that is hidden or unavailable in a textual representation. In the real world, individuals use social cues and information from other people in order to find their way and inform decisions. Social navigation cues are also valuable in the digital domain, with the movement of people around online communities, and the activity within chat rooms or bulletin boards helping to guide or inform decisions (Dieberger et al, 2000). Visualisations can in some ways go beyond normal human interaction, providing a visual summary of communication that would not be possible in face-to-face contact.

3.4 Designing Successful Visualisations

A key challenge of visualisation is inventing visual metaphors and developing new ways of manipulating existing metaphors to make sense of information (Eick, 2001). The salient data should be identified and represented accurately and intuitively in a visualisation. These ocular aids to cognition benefit from good visual representations of a problem, and from interactive manipulation of those representations (Card et al, 1999). People require indicators that allow them to make decisions and interact (Dieberger et al, 2000). Within an online community, these indicators enable users to access and assess activities within different functional areas such as chat rooms, bulletin boards, etc.

Erickson (2003) proposes six claims for designing visual representations of group activity in online environments:

- (1) *Everyone sees the same thing; no customisation.* Every user should be able to see the same thing and users should not be able to hide their own actions and activities from other users. The power of the visualisation comes from the fact that everyone sees the same thing and every user knows that this is the case. This mutuality supports people being held accountable for their actions, and leads to useful social phenomena such as feelings of obligation and peer pressure.
- (2) *Portray actions, not interpretation.* Systems may end up being used in unexpected ways. Users should be left to interpret the visualisations rather than build interpretations into the system with particular usage situations in mind. Users understand the context better than the system ever will and, as such, they should be left to draw their own interpretations.
- (3) *Social visualisations should allow deception.* If users wish to trick the system they should be allowed to do so. Just as users in face to face interactions may feign interest or project impressions that do not represent their underlying feelings, this should also be possible online.

- (4) *Support micro/macro readings.* A visualisation should be made up of small components which persist. Information will grow into recognisable patterns at multiple levels over time.
- (5) *Ambiguity is useful: suggest rather than inform.* Incomplete and distorted representations are inevitable. The primary role for visualisations is to provide information to enable inferences. The visualisation will not be a perfect reflection of deeper conversation. The views provided will create user insight and users will become comfortable with making best guesses from incomplete information.
- (6) *Use a third-person point of view.* Users need feedback on their own activity and they learn to interpret social visualisations through observing it over time and by seeing their own activity reflected in the visualisation. Visualisations should show users their own activity as others would see it.

If a visualisation is to be successful, it must have good usability. Preece (2001) outlined a range of determinants of good usability including: speed of learning to use the interface (should be high in successful communities); retention, i.e., how much a user remembers about the mechanics of interacting with the online community software (should be high in successful communities); productivity, i.e., how long it takes to do standard tasks such as reading or sending, searching, etc. (should be high); the number of errors that occur when doing communication tasks (should be low); and users' satisfaction using the software (should be high).

Allied to this, visualisations should not be overly complex, making them difficult to comprehend from a user's perspective. As noted by Tufte (1983), embellishment of charts with unnecessary lines and shading, what he calls 'chartjunk', merely serves to hinder the user's judgmental accuracy. If a visualisation is not usable, its provision will be counterproductive as users will be discouraged from using it, and this may ultimately cause them to stop returning to the online community. Systems with good usability will make tasks easier and quicker to do, and this is a key factor in encouraging contributions within a community given that the aim is to reduce the time required to participate (see section 2.8.4). Given the challenges in motivating

people to contribute, bad user experiences could turn away many potential participants (Girgensohn & Lee, 2002).

Visualisations are successful if they are intuitive, easy to use, easy to access and visually engaging (Donath, 2002). The key challenge in developing successful visualisations lies in identifying elements and techniques to depict the people, activity, vitality and milieu in online communities (Lee et al, 2004).

3.5 Avatars

Avatars that simulate physical presence are a frequently used technique in gaming environments and chat systems such as ActiveWorlds⁸. VZones⁹ also allows primitive expressions from avatars through the use of expression buttons, and keyboard shortcuts that enable users to change the avatar's face to support expressions such as a frown or a smile. However, screen real estate limitations pose problems in showing more than a few avatars at any one time, with too many avatars causing the screen to become cluttered. Furthermore, avatars tend to suffer from a limited range of expressions that overlay a user's communications, and this can ultimately distort the user's expression or intent (Viegas & Donath, 1999).

Even if avatars have a wide range of expressions, they still fall well short of the subtlety of verbal expressions or physical gestures. Systems such as BodyChat (Vilhjálsson & Cassell, 1998) interpret the user's input and expand it into a more complex performance drawn upon social knowledge. However, this approach involves some unintentional expressivity that may not match the user's intent (Donath, 2001). The same problem applies to systems that take the user's writing (Nass et al, 1994; Ostermann et al 1998) or speech (Eisert et al, 1997) as the input to derive expression and drive the animation.

⁸ <http://www.activeworlds.com/>

⁹ <http://www.vzoners.com/>

In addition to problems of expressivity, the appearance of chat rooms crowded with avatars may also be misleading if the majority of those depicted are passive and not contributing. Despite being logged in, some of the users may in reality be far from their computers (Donath et al, 1999).

The limitations of avatars has lead to the development of a variety of smaller, more abstract graphical visualisations that support social presence and give users a more informed perspective on community activity. Smaller graphical representations are easier to produce and manipulate, and persist over time leaving impenetrable traces that are helpful to users (Erickson & Kellogg, 2000). Therefore, the visualisations considered in the remainder of this thesis will tend to focus on such smaller, abstract graphical representations. The next section considers how abstract visualisations have been used to depict site traffic.

3.6 Visualising Traffic

An increasing amount of research has focussed on visualising the presence of visitors at websites as a way of making people and their activities explicitly visible to other users. The provision and visualisation of historical information of this nature can assist users' social navigation, informing users about the digital trace left by previous users (Wexelblat, 1999; Dieberger et al, 2000).

WebMap (Xiong & Brittain, 1999) visualises activity at a website by developing a visual site map in the form of a floor plan. It represents the presence of individual users over time as dots in various areas of this floor plan, with different coloured dots used to depict visitors from different domains (Figure 3.1).

Figure 3.1: WebMap



Source: Xiong & Brittain, 1999.

Individual visitors' site traversal is depicted by movement of the dots around the site map and several dots accumulate in various sections of the site map as a means of identifying those web pages which are visited most often. However, there are two main difficulties with this approach. Firstly, the specific visual floor plan used to signify the site map would need to be modified for every single site that the visualisation was used on, and limitations of screen real estate would make this even more difficult for large sites with many sections. Secondly, the use of separate dots for each individual user would not be feasible on sites with large amounts of traffic as there would not be enough space to depict each individual user separately.

Similar work by Minar & Donath (1999) utilises a site map and shows the historical movement of individual users, in the form of dots, to visualise the crowd dynamics of visitors (see Figure 3.2). However, in both cases the provision of individual detail in this manner would make it difficult for users to obtain a gestalt for what was

happening. Furthermore, displaying historical traversal patterns in this manner means that users have to sit and watch videos of prior site activity.

Figure 3.2: Visualisation of Crowds at a Web Site



Source: Minar & Donath, 1999.

Jung & Lee (2000) visualised the presence of users by aggregating co-located people as a crowd rather than representing individual users at the site. Each link in various sections of the site menu has an accompanying flashing dot that represents the density and dispersal of people within the site (see Figure 3.3).

Figure 3.3: Aggregation of Crowds



Source: Jung & Lee, 1999.

This approach enables users to make use of collective information about anonymous gatherings of people and of the salient activities to guide their behaviour, action, decisions and interactions at the site (Whyte, 1988). The combination of salient information in this manner, rather than showing detailed information of the traversal of individual visitors, means that this form of visualisation is more scaleable and takes up less screen real estate. While this approach means that users can instantly gain an overview of prior activity in an immediate snapshot, the amalgamation of user activity into one coloured dot raises questions over the colours to be used, the number of different colours to signify different levels of activity, and also the level of activity required within an area before the colour of the dot changes. None of these issues are covered by Jung & Lee.

While the visualisation of traffic is an important area, users of online communities are primarily concerned with finding out whether their own interests are congruous with the interests of the community and other users. As outlined in section 2.4.2, when the collective purpose of the community is consistent with the goals of individual members, this will help to foster a sense of community and generate social interaction. As part of their information-discovery phase, users typically seek to find out whether there are resources or other users that match their own interests, and also whether there are ongoing conversations of interest. Therefore, the remainder of this chapter will focus on matching interest and bulletin board visualisations.

3.7 Matching Interest Visualisations

As discussed in section 2.7, users generally seek to discover information about a community before becoming more active participants. As part of this phase, they browse in order to get an overview of the community content, looking for resources of interest or trying to find information about other members of the community (Warms et al, 2000b). Given that many online communities may be viewed as communities of interest, it is highly appropriate that users seek to find out whether the interests of the community match their own. When the interests of the community as a whole are in line with the interests of individual members, this will help to

engender a sense of community and foster increased levels of social interaction between members.

Recommender systems address problems of information overload and help users choose from large sets of items from which they may have little or no first-hand knowledge. Recommender systems such as that operated by Amazon¹⁰ suggest items that users may be interested in buying, based on their previous search and purchase history. In addition to suggesting items, social matching systems can also recommend other users to people. People are fundamentally social creatures and there is an increasing body of research on the use of social matching systems to bring users closer together (Kautz et al, 1997; McDonald & Ackerman, 2000; McDonald, 2001; Budzik et al, 2002; Terry et al, 2002).

Visualisation based on such matching interest systems may be useful in online communities, either suggesting resources that may be of interest or visualising like-minded users based on previous interactions within the community. Providing these suggestions in the form of a visualisation gives users an overview of other resources and users that match their own history and profile. The provision of matching interest visualisations can act as a driver towards increased levels of interaction and collaboration as users link up with people who share similar interests (Hattori et al, 1999; Terveen & McDonald, 2005).

Matching interest visualisations convey information about an online community and its members, helping users decide whether a community is one they would like to join and also whether there are other members they would like to converse with. In doing so, they attempt to bring people together by identifying specific members that a user may wish to converse with (Terveen & McDonald, 2005). I2I is one such system that uses information retrieval techniques to profile users' activity based on web pages that they visit, applying text similarity metrics to cluster users who are browsing similar documents (Budzik et al, 2000; 2002). Users with similar interests are considered good matches and I2I suggests possible connections between these

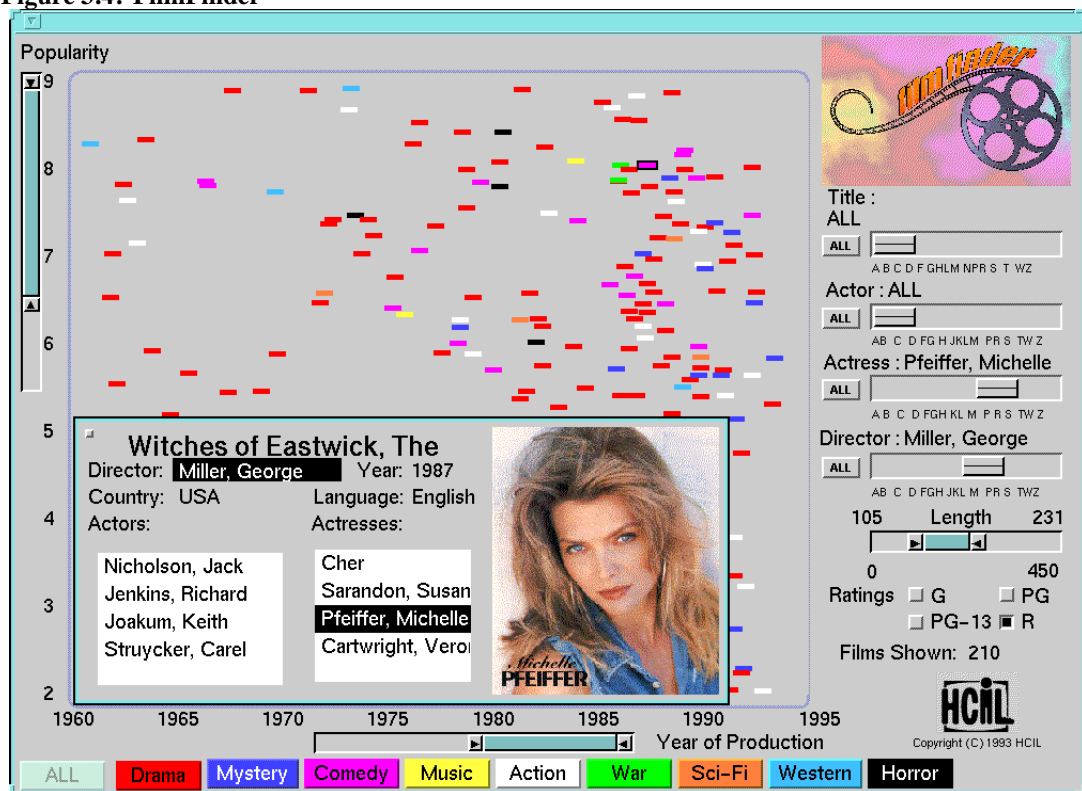
¹⁰ <http://www.amazon.com>

users. EFOL (Svensson et al, 2001) uses a similar system to organise recipes into collections and shows interaction history, enabling users to identify the most popular collections.

This remainder of this section considers previous work that visualises items of interest within an online community context, focusing primarily on the efficacy of the visualisations in suggesting similar resources or users, rather than any underlying matching algorithms.

FilmFinder utilises dynamic query filters to help users find films of interest (Ahlberg & Shneiderman, 1994). Sliders and radio buttons are used to select value ranges for variables when choosing films, enabling users to make rapid, incremental and reversible changes to query parameters. The query result in FilmFinder is continuously represented in a Starfield display (see Figure 3.4) with the X-axis representing time (year of production) and the Y-axis depicting a measure of popularity (ratings).

Figure 3.4: FilmFinder

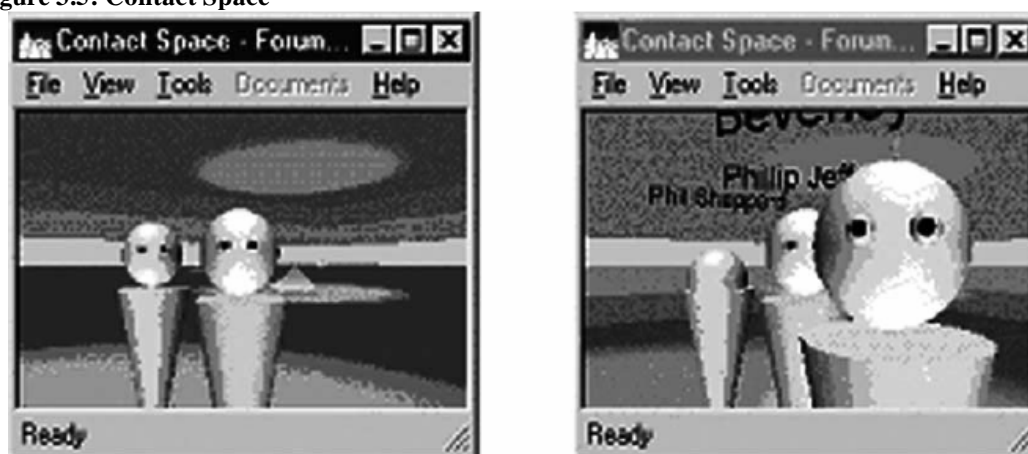


Source: Card et al, 1999.

While FilmFinder provides an overview of films split by production year and rating, it does not take into account the history of the user in terms of other films that they have watched. The system is aimed solely at finding films in the database, and does not incorporate any sort of social matching system that may inform the user of other people with similar interests. For example, a visualisation could show other users who have watched similar films, thus providing the opportunity for members to talk with other members who share the same taste in movies.

Contact Space was developed to facilitate communication and information sharing where there are mutual concerns or interests across communities of practice (Raybourn et al, 2003). The system utilises profile matching, and users are depicted in the form of avatars which dynamically move to designated spaces in a collaborative virtual environment in order to enable communication between members. Contact Space determines which users are most similar to each other and then moves the avatars closer together depending upon their similarity, directly facing the user who is the best match (see Figure 3.5). In addition to users, resources of interest are also shown in the visualisation. For example, there is a pyramid depicting a topic of interest in the first screenshot in Figure 3.5.

Figure 3.5: Contact Space



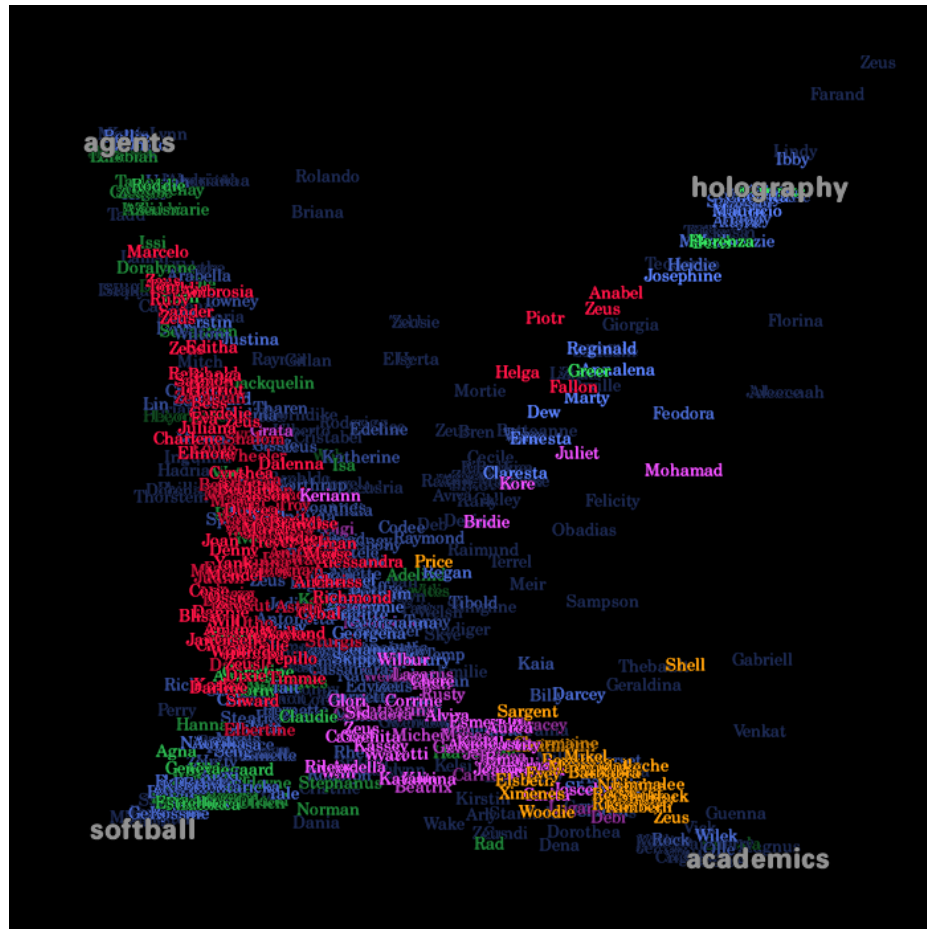
Source: Raybourn et al, 2003.

Due to the size of the avatars used in Contact Space, it can be quite difficult to distinguish all users and resources of interest as the nearest avatar masks other items

which are directly behind it. The size of the avatars also means that the number of items that can be displayed on the screen at one time is severely restricted. Furthermore, despite usernames being displayed above each of the avatars, these can be quite difficult to distinguish, especially when there are several avatars displayed on screen at the same time.

Visual Who uses a spring model to visualise member affiliation within online communities, bringing together people who have shared interests in a given area (Donath, 1995). Users choose groups to place on the screen as anchor points and the names of community members are pulled to each anchor by a spring, the strength of which is determined by the individual's degree of affiliation with the group represented by the anchor. Multiple anchor points can be placed on the visualisation to denote users' degree of interest in multiple areas. When anchors are moved, the names of the users who are closely affiliated with that group also move and as anchors are deleted, the names that had been pulled towards it are released and spring away. Colour is used to signify different roles of users and in the example in Figure 3.6, colour is used to distinguish different academic roles including faculty, graduate researchers etc. The brightness of the colours is used to signify the relative strength of all the springs attached to a name, and brighter names show which users are most interested in the aspects of the community which are currently highlighted by the anchors.

Figure 3.6: Visual Who



Source: Donath, 1995.

While Visual Who provides a visualisation of which users have similar interests in certain areas, it can be hard to distinguish individuals where there happens to be a large cluster of users. Therefore, if members are trying to identify other users with similar interests, the clustering effect may cause legibility issues, which could make it exceedingly difficult to pick out individual users. As was the case with Contact Space, Visual Who can at times be difficult to decipher as the visualisation becomes crowded, and this could potentially discourage people from using them.

Community Organizer provides visualisations of community members and the communication exchanged between those members, reflecting the interests shared by them (Kamei et al, 2001; 2002). It aims to help users find other people with similar interests and encourage communication between them. Within Community Organiser, users can place multiple icons within the visualisation to signify their

interests in a range of areas, and these icons are then reflected in the visualisations of all other users. The icons of users with similar interests are placed closer together and sliders are used to change the user's degree of interest in a range of categories that have been set out by the system administrator. The use of these sliders results in the placement of icons moving to reflect their modified interests (see Figure 3.7).

Figure 3.7: Community Organizer



Source: Kamei et al, 2001.

As was the case with Visual Who, Community Organiser concentrates on visualising other users, and does not depict potential resources in the visualisation. While Community Organiser provides an easy to understand visualisation of user interest based on a set of feature vectors, it relies upon users placing their icons on the visualisation in order to reflect their interests, and some users may be reluctant to do this. Furthermore, as users' interests shift over time, the system relies on users updating their preferences by shifting or moving their icons to reflect these updated interests. Allied to this, the fact that users are able to place multiple icons on the display to reflect a range of interests means that each user who has chosen to place an icon on the visualisation may actually be displayed more than once and this may cause confusion for some users. However, the main drawback of Community Organiser is that users can only specify their interest in a range of categories that have been determined by the system administrators. This means that the operation of

the system is highly reliant on the system administrator responding timeously to the changing needs, interests and requirements of the community's users as and when they may arise.

3.8 Visualising Conversations

Although it is important for users to find out if the interests of the community are congruous with their own, the vibrancy of a community is ultimately dependent upon the conversations that take place between users (see section 2.8). Therefore, it is important to develop enhanced interfaces that will more readily support communication between users. There are a number of enhanced interfaces and visualisation techniques that are currently being used to promote user interaction and dialogue on the web, utilising simple, compact and legible visualisations to highlight patterns and convey aspects of the social context in the online environment. A range of these different visualisation techniques across bulletin boards, chat rooms and newsgroups will now be considered and analysed in order to assess their efficacy in augmenting and enhancing online communities.

As discussed in section 2.8, asynchronous forms of discussion such as bulletin boards and online forums are more suitable for online communities because they are not constrained by chronology or distance, and are more suited to geographically-dispersed online communities. The asynchronous aspect of these discussions allows community members to check for messages at their discretion and also enables them to be more active and reflective in their comments. Despite the fact that asynchronous forms of communication are preferable in online communities, visualisations of synchronous forms of communication such as chat rooms will also be considered in the following sections in order to gain an insight into a wider range of possible techniques to visualise online communication.

There are two key characteristics that are important in visualising online conversations. First, it is important to be able see the temporal development of discussions (Venoila & Neustaedter, 2003) as this provides a sense of the vitality of

discourse and the urgency with which messages were sent. Second, it is important to be able to identify the participants in the conversations and their patterns of interaction (Donath et al, 1999) as this provides an understanding of the basic social structure of the dialogue.

These characteristics enable the visualisation of a wide range of information that depicts the milieu, people and activity within conversations in online communities. The visualisations can be used to trace threads, find active posters and identify communication patterns between users. The review of the various visualisation techniques that follows shows that the type of information that can be visualised includes:

- overview of thread structures
- general level of activity
- number of threads (both historically and currently active)
- length of time a thread has been active
- number of posts in a thread
- most recently active threads
- threads with most messages
- temporal development of threads and posts
- identification of messages posted by individual users across threads
- number of users posting messages in and across threads
- frequency of posts from users
- extent to which threads are dominated by certain users.

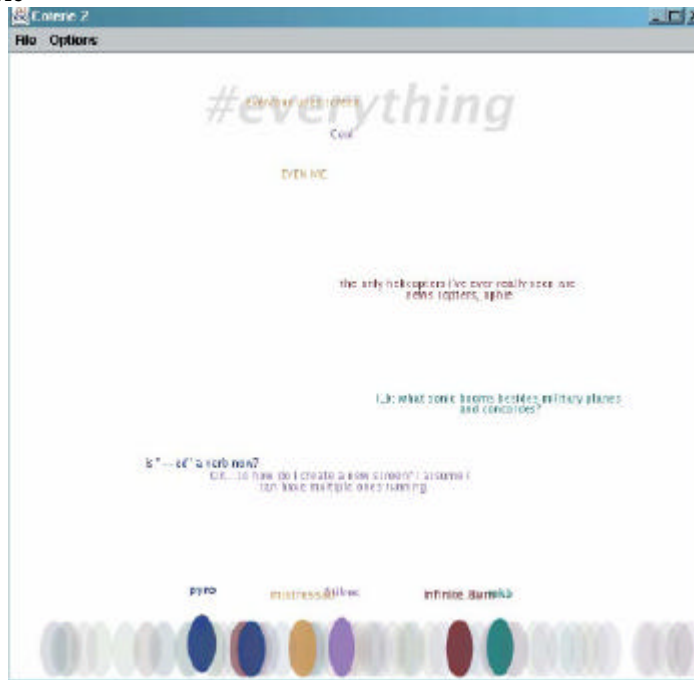
The ability and efficacy of visualisations to depict this type of information will be considered as they are discussed.

3.8.1 Chat

Coterie (Donath, 2002) visualises IRC¹¹ activity, taking account of participant activity and the structure of conversations. All participants who are logged on to IRC (both active and passive) are depicted by coloured ovals that bounce and become brighter and larger as users speak, thus conveying the vitality of discussions (see Figure 3.8). Active participants are shown in the centre of the group, while lurkers are depicted on the periphery. Ovals eventually shrink back to their original size and become more transparent if users do not post any more messages, and the ovals start to move back to the edge of the group. Coterie uses heuristics to determine the relationship between messages. It attempts to sort conversational threads chronologically by looking for repeated key words and phrases, and occurrences of specific individuals being addressed. Related messages are grouped within a sequential stream, with multiple message threads running in parallel within chat sessions. These threads are used to group the coloured ovals together where conversations are taking place. Coherent discussions form a solid central core on the screen, while scattered chats are spread across the screen, thus allowing individuals to identify vibrant conversations and possibly join them.

¹¹ Internet Relay Chat

Figure 3.8: Coterie



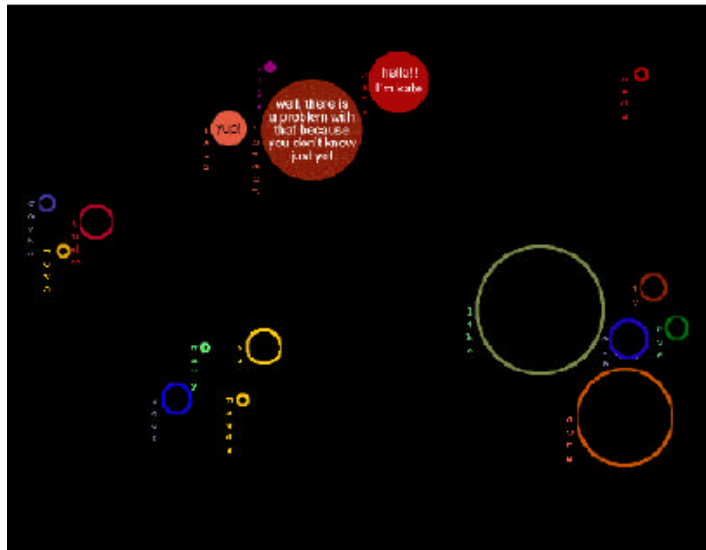
Source: Coterie, 2002.

The visualisation approach taken by Coterie takes advantage of the real-time synchronous nature of chat rooms with users watching dynamic visualisations that change in real-time as messages are typed. However, such an approach would not be suitable for visualising asynchronous bulletin board activity due to the fact that it fails to give an overall snapshot of the interaction history, and users would have to watch historical animations in order to get an idea of prior activity.

Chat Circles (Viegas & Donath, 1999; Donath et al, 1999) uses coloured circles in visualising the activity of online chats (see Figure 3.9). Each user is drawn separately, represented by separate circles in the visualisation. Chat Circles groups people together in conversations based upon the proximity of users within each chat room and the visualisation gives a good graphical display of 'turn-taking' within a synchronous communication environment. The size of a user's circle expands, and the colour of the circle brightens, as soon as a message is typed. After the message has been posted, the circle gradually decreases in size and rises up the screen with the vertical axis depicting the time since a message was typed. The text of each message is displayed within the user's circle and participants are free to move their circle around the screen. In fact, users are motivated to do so by the fact that

although users can see all other participants, they can only ‘hear’ (that is, read the words of) those that they are sufficiently close to.

Figure 3.9: Chat Circles

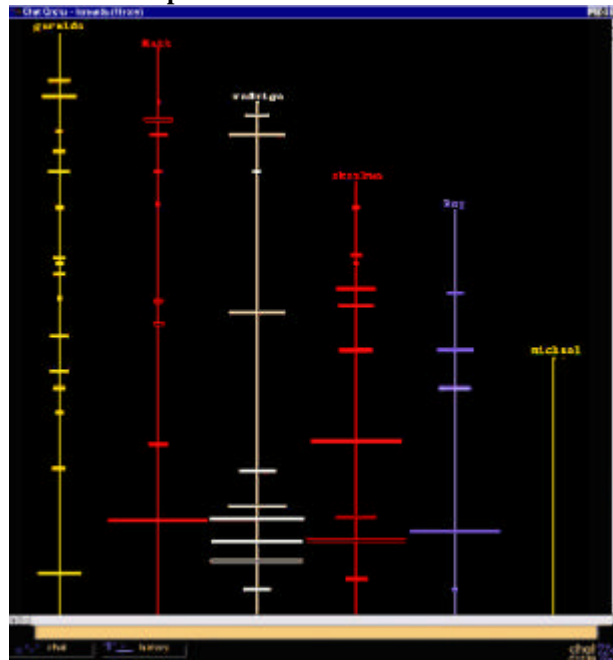


Source: Viegas & Donath, 1999.

However, the use of separate representations for every individual would not lend itself to application within bulletin boards given the threaded and asynchronous nature of communication within bulletin boards, where it is not uncommon for individuals to participate in several threads at once.

In addition to the primary ‘real time’ visualisation, Chat Circles also has a separate visualisation of archived chats named Conversation Landscapes which allows users to see the history of chat sessions (see Figure 3.10). Once again, the time between messages is depicted vertically and each user is depicted by a colour-coded vertical line. Echelons are drawn on the vertical lines to depict when users have posted a message, and the width of each echelon depicts the length of the message.

Figure 3.10: Conversation Landscapes



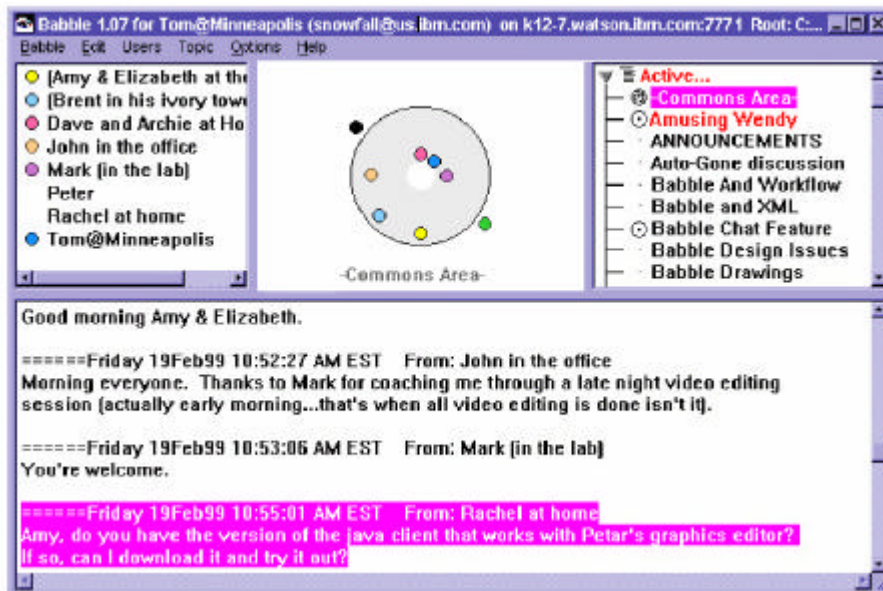
Source: Viegas & Donath, 1999.

While Conversation Landscapes shows an excellent depiction of the archived history of individual users, if one wishes to examine the history of a chat, this involves looking across a range of lines to look at the involvement of every single individual user. As was the case with the real-time visualisation of Chat Circles, this visualisation would not lend itself to use with bulletin boards given the threaded and asynchronous nature of communication within bulletin boards where it is not uncommon for individuals to participate in several threads at once.

Erickson & Kellogg (2000; 2001; 2003) use the term ‘social translucence’ to refer to systems that support visibility, awareness and accountability to support communities of practice. They designed their socially translucent system to provide cues about users’ presence and activities as a means of supporting communication and collaboration in their online groups. Babble is a visualisation of a chat environment developed to support small to medium-sized corporate work groups in a community of practice for IBM researchers (Erickson et al, 1999; 2002; 2006). Babble makes use of ‘social proxies’ in the form of small coloured circles, or marbles, to graphically represent different users and their activities as a means of supporting long-term conversations within existing groups (see Figure 3.11). A further feature of Babble

that separates it from other chat systems is the concept of persistent conversation – conversations are logged, meaning that they are constantly visible to participants. The relative positions of the marbles represent who is talking to whom, and who the most active participants are. When a user is typing a message, their marble moves to the centre of the display, and gradually drifts back out in periods of inactivity.

Figure 3.11: Babble



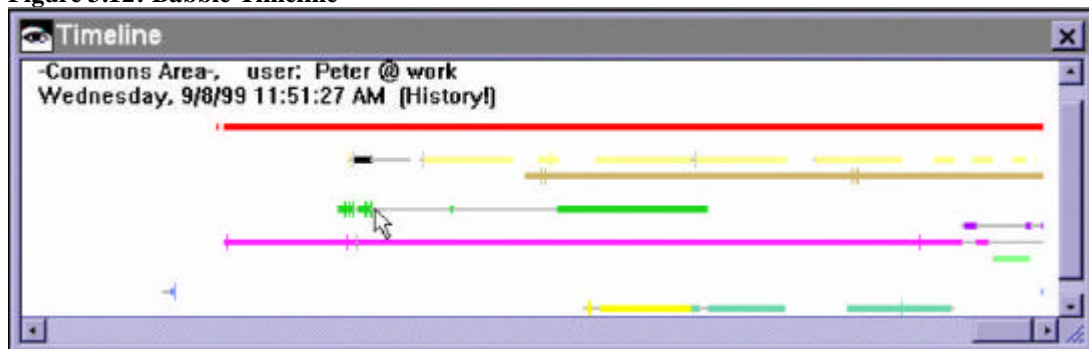
Source: Erickson et al, 2002.

Babble shows the position of all users present in the chat room, meaning that lurkers are also shown. In cases where there are people who do not wish to be seen, this type of representation may pose a threat to their continued membership of a community, and may actually stop them participating (Preece & Maloney-Krichmar, 2003). However the primary problem with Babble is a shortcoming that is common across the majority of chat visualisations – they only show the presence and activity of users who are currently logged on, and any historical context can only be garnered through watching an animation of previous interactions. As a result, visualisations such as Coterie, Chat Circles and Babble fail to give an easily accessible overall snapshot of the interaction history. This limitation resulted in the development of a Timeline social proxy within Babble as a means of supporting more asynchronous interaction. Given that one aim of providing visualisations is to reduce the amount of time spent by users during the information-discovery phase, more abstract depictions which

give a snapshot of the interaction history would appear better suited to achieving this goal as they would enable users to get a quick overview of the previous conversational context.

Under the Babble Timeline visualisation, each user is represented by a separate row which leaves a line or trace when they are logged on (see Figure 3.12). A vertical mark appears on the line to signify when the user was speaking, and the line is shown in colour if the user was present in the conversation currently being viewed.

Figure 3.12: Babble Timeline



Source: Erickson & Kellogg, 2003.

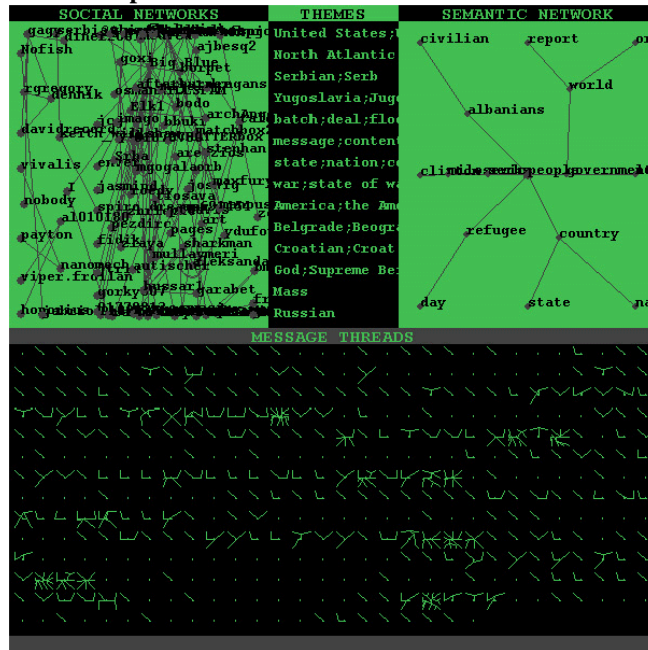
This visualisation helps in understanding the usage patterns of the community, highlighting ‘hot’ times when people tend to log in or make a contribution. However, as was the case with Conversation Landscapes, this visualisation would not be directly suited to use in a purely asynchronous environment such as a bulletin board given that users frequently participate in more than one thread at a time, and threads tend to develop over longer periods of time

3.8.2 Usenet

Conversation Map (Sack, 2000) uses node-link graphs to display Usenet threads and users’ interaction networks (see Figure 3.13). It uses an array of radial tree thumbnails in the form of ‘spider webs’ in the bottom part of the visualisation to depict messages in a particular newsgroup. Conversation trees can be opened to show detail about social networks, discussion themes and a semantic network. The social

network view represents people as separate nodes, showing responses and messages between participants. The discussion themes portion of the visualisation uses lexical cohesion to summarise the main themes in the Usenet threads and the semantic network area links terms that have been talked about in similar ways in the archive of group messages.

Figure 3.13: Conversation Map



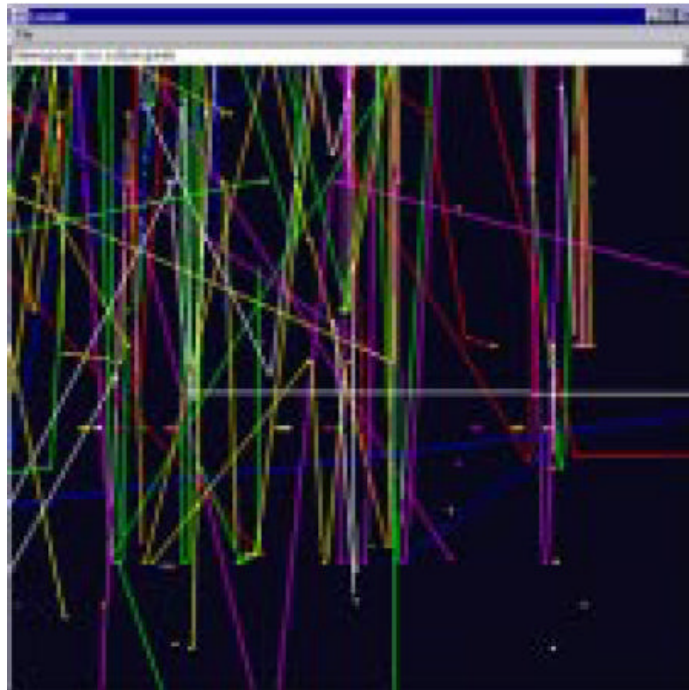
Source: Sack, 2000.

The approach taken by Conversation Map takes the linguistic content of messages into account when showing connections. However, it fails to represent the chronological sequence of messages, making it harder to see how threads have developed. There is also no indication of temporal thread development, making it difficult to see how threads have developed over time. Although the visualisation shows which user has posted in individual threads, it is not possible to see which users have posted messages across multiple threads. It can also be hard to distinguish the pattern of conversation between users as the social network view becomes densely populated with multiple messages.

Loom (Donath et al, 1999) also visualises the activity within Usenet newsgroups, using a fabric analogy to refer to the threads of a Usenet group and also to the

patterns and texture of the events within the group that are reflected in the digital fabric (see Figure 3.14). Each message is placed on a 2D plane with the horizontal axis representing time and each individual author being shown on a new row. Lines are used to connect any replies and different conversations are represented by different coloured lines. The dots are clickable, with a separate window being opened up to show the message contents. Loom provides a means for traversing the threads and discovering the individual postings. By representing the postings in this form, it captures not only the patterns of usage, but also a historical context for the postings.

Figure 3.14: Loom



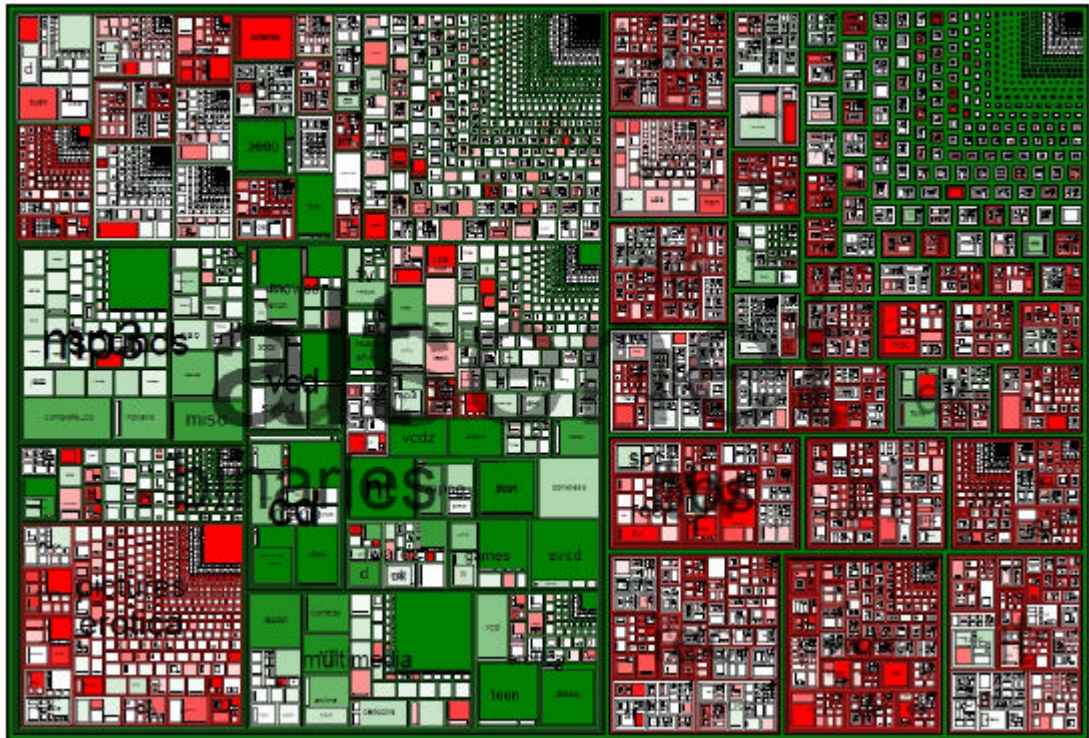
Source: Donath et al, 1999.

While Loom visualises the connections between users in terms of their replies, like Conversation Map this approach can make the visualisation hard to decipher as the lines depicting replies cross each other, making the visualisation quite cluttered. This approach also makes it hard to make out the overall thread structure and temporal development of discussions, with quite a lot of scrolling required looking up and down the visualisation to pick out individual replies to messages.

Netscan (Smith & Fiore, 2001; Smith, 2002) rendered the entire Usenet (see Figure 3.15) using a tree map approach, presenting a view in which newsgroups, represented

by rectangular regions, are nested within their hierarchies and have volumes equal to their cumulative number of posts. Variations in colour indicate the change in the number of messages posted for the current month compared to the previous month. Green means that the number of posts in that particular newsgroup increased, while red indicates that the number of posts decreased, with a higher intensity in colour showing a greater change in the number of posts.

Figure 3.15: Netscan Visualisation of Usenet (November, 2002)



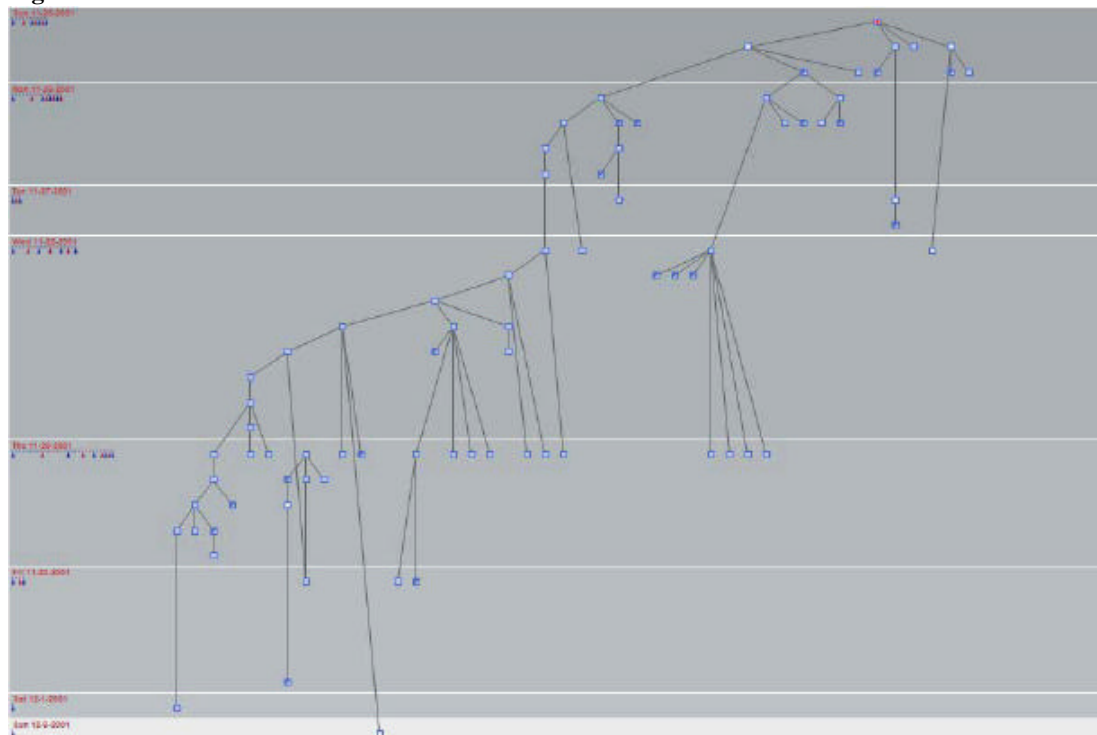
Source: Netscan¹².

The tree map approach gives a good overview of the scale of Usenet, showing those areas which are expanding and contracting over time. However, this view is static and one useful addition to this would be the ability to zoom in on particular areas of the map to see more detail. Although the Netscan website allows users to view historical Usenet maps by calendar month, there is no functionality for separate views apart from either a global view or a view of the microsoft.public hierarchy, meaning that it is impossible to get a meaningful overview of the level of activity in other hierarchies or even in individual newsgroups.

¹² <http://netscan.research.microsoft.com>

Netscan also displays a visualisation of individual threads in a newsgroup using a tree structure (see Figure 3.16). The initial message appears as the root at the top of the tree and successive messages branch out downwards from there. Grey bands are used to represent calendar days on which messages are posted throughout the life of the thread. Days on which there are no messages are not shown, but are suggested by a more dramatic shift in shading to the next band.

Figure 3.16: Netscan Thread Tree



Source: Smith, 2002.

The Netscan thread trees provide an excellent view of the message sequences in individual threads. But this visualisation only shows one thread at a time, meaning that multiple threads cannot be compared visually and users cannot compare the distribution of posters across threads. This means that there is no way of identifying users who are prominent posters across a range of threads. Although a user may only post one message in a particular thread, they may be more active across a range of other threads, and such information concerning patterns of interaction would not be immediately clear from examining the visualisation of one thread in isolation.

Within the visualisation of a thread, the position of messages in the grey bands is also somewhat misleading as the positioning along the vertical axis in a particular day depends solely upon the number of messages that need to fit above and below the particular message in the band, and not upon the time of day that the message was posted. While Netscan does highlight the author of a thread along with the most prolific poster, it fails to visually identify each separate author, meaning that it is not possible to visually examine the distribution of different authors across the life of a thread.

Newsgroup Crowds uses a scatter plot to visualise the activity of participants in a newsgroup over the course of a month (Viegas & Smith, 2004). Each author is represented by a circle whose placement is determined by the two axes: the number of days in which they have posted a message on the vertical axis, and their average number of posts per thread in the newsgroup on the horizontal axis (see Figure 3.17). A contributor's circle changes shade, becoming brighter if they have recent posting activity, and becomes larger if users have contributed more posts to Usenet as a whole.

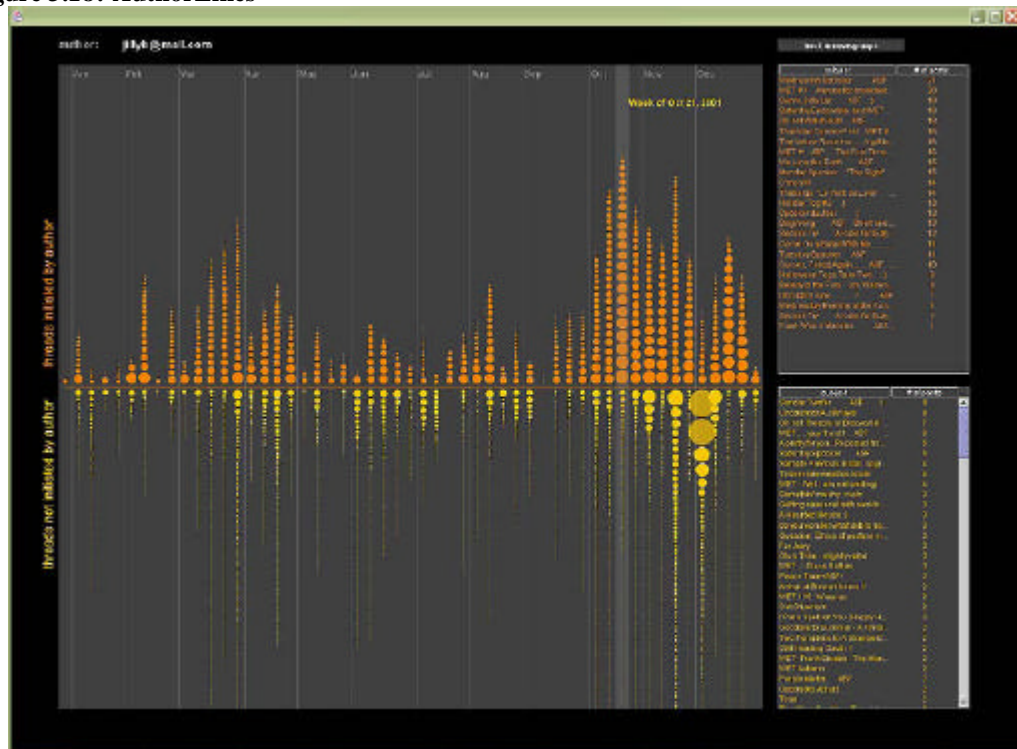
Figure 3.17: Newsgroup Crowds



Source: Viegas & Smith, 2004.

Viegas & Smith (2004) also developed AuthorLines to visualise an individual's posting behaviour across newsgroups over an entire year. It shows a horizontal timeline with vertical monthly dividers. Months are displayed along the top of the visualisation and vertical lines of circles represent weekly activity. Each circle represents a thread to which the user has contributed during that week, and larger circles show that the user has contributed more messages in that particular thread. AuthorLines differentiates between threads started by the user and those that were not. Orange circles are placed above the timeline to signify threads they started, and yellow circles are placed below the timeline to depict threads they did not initiate (see Figure 3.18).

Figure 3.18: AuthorLines



Source: Viegas & Smith, 2004.

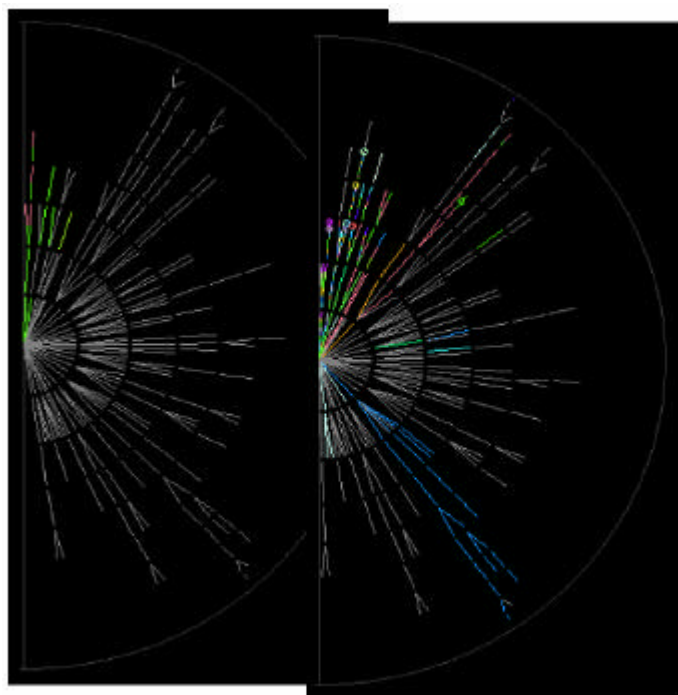
Newsgroup Crowds provides information about the history of individual users' interaction in specific newsgroups, while AuthorLines emphasises a single user's sequence of messages and replies. However, they both fail to take into account the overall interaction context, and they do not show the structure of threads in which the messages are posted, meaning that it is not possible to identify either patterns of interaction in threads or the temporal development of discussions. Furthermore,

while it is useful to know that a user may have started a number of threads, it is equally important to find out if any other users have replied to these threads as if there are no replies to a sequence of threads from the same user, this will send a signal of how their opinions are valued by the rest of the community.

3.8.3 Bulletin Boards

WebFan (Xiong & Brittain, 1999) visualises web-based bulletin board activity using a fan-like hierarchical structure, allowing forums with multiple threads to be represented at the same time for overview and comparison purposes. Threads are incorporated into a fan-like structure, and lines on the fan change colour to depict that a given posting has been read (see Figure 3.19).

Figure 3.19: WebFan



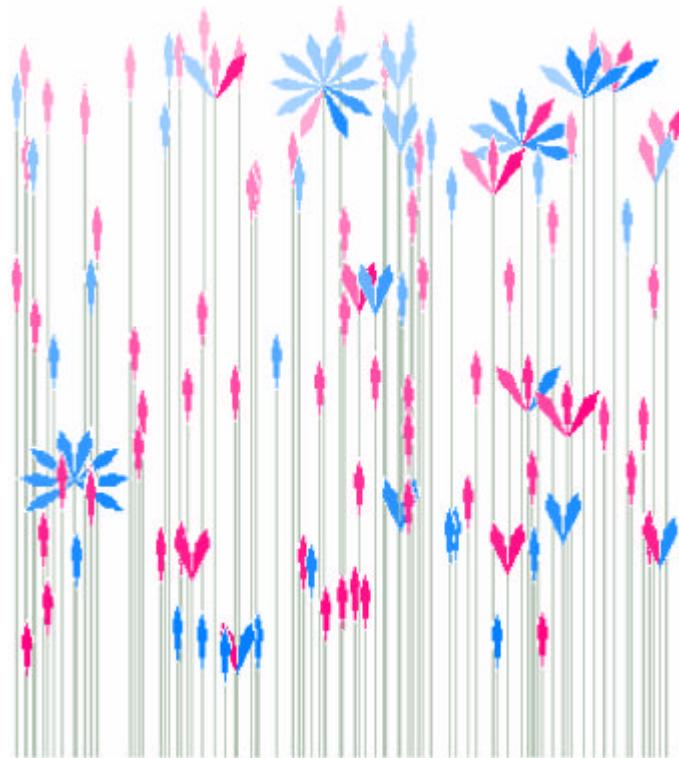
Source: Xiong & Brittain, 1999.

While WebFan enables the user to gain an overview of postings and replies, it fails to include a range of elements which would be useful to potential users. From the visualisation, it is not possible to look across threads to see which users have posted which messages – a limitation that was also common to both Netscan and

Conversation Map. Were it included, such a feature would be helpful to potential users in order to get an overall picture of posting patterns and of the most prolific users within the bulletin board. Furthermore, as was the case with Loom and Conversation Map, there is no indication of temporal thread development which, were it indicated, would allow a user to see how long a thread has been active, the length of time between postings in a thread and the comparative timeline of each thread.

PeopleGarden (Xiong & Donath, 1999) uses a botanical flower and garden metaphor to visualise user activity within a bulletin board, providing static portraits of users' participation in online communities (see Figure 3.20). Each bulletin board participant is represented by a separate flower and long plant-like stems depict the length of time the user has been an active participant, with longer stems representing a user that has been active for a longer period of time. Petals are used to signify each post that has been made with red signifying initial postings and blue depicting replies. Collections of flowers, or gardens, are used to portray the contributions and posting patterns of every participant within the bulletin board. A visualisation of a fading group with only a few participants who have dominated and occasionally still check in resembles an overgrown and neglected garden. A bulletin board with a mixture of newer and older participants who both start and reply to threads will be depicted by a thriving and varied garden with a mixture of tall lush flowers and new buds.

Figure 3.20: PeopleGarden



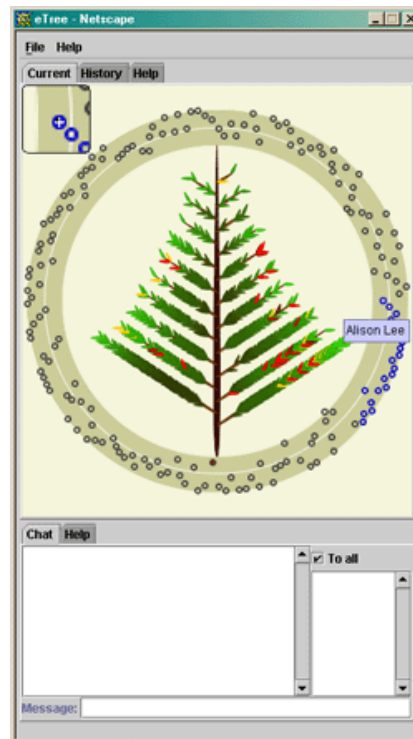
Source: Xiong & Donath, 1999.

Although PeopleGarden provides an excellent visualisation of the behaviour pattern of individual members and their contribution levels, it does not show information about overall thread structure. There is no information about the size of threads, temporal development of threads, length of time that threads have been ongoing, or the distribution of users across threads in the bulletin board. In addition, while visualisations such as PeopleGarden provide information about the activity of various individuals, they fail to convey the context in which this activity takes place; there is no visualisation of the overall social activity context. As was the case with Newsgroup Crowds and AuthorLines, although it may be useful to know the activity and level of contribution of individual users, there is also a need to contextualise this information by visualising the activity of the group or community as a whole, showing information such as most popular threads.

Another botanical approach to visualising online conversation is that of eTree (Zhang & Lee, 2002; Lee et al, 2004) which uses a visual ecosystem metaphor to map discussions into a tree-like structure (see Figure 3.21). Each branch on the tree

depicts a separate discussion forum with leaves on the branch depicting a separate discussion thread, meaning that the branches grow longer as more threads are started. Individual users are also represented on the visualisation as coloured circles around the perimeter ring surrounding the tree. New threads are shown in light green and older threads turn dark over time. Active threads are depicted by bright yellow leaves, while threads that have many authors are shown in red to signify a hot topic.

Figure 3.21: eTree

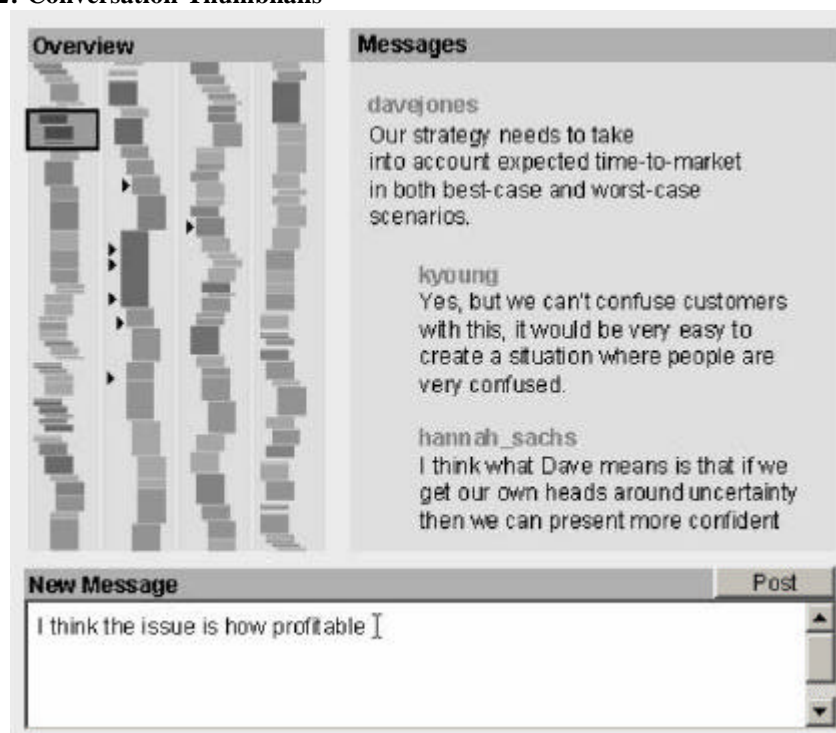


Source: Lee et al, 2004.

While eTree provides an excellent visualisation of the overall structure of a large bulletin board with several separate forums, it does not provide any detail about the size of each individual thread in terms of the number of posts. Nor does the visualisation provide any information about the temporal development of those threads. It is also not possible to compare the development of discussions across threads. Furthermore, as was the case with Conversation Map, Netscan and WebFan, it is not possible to ascertain which users have posted in which threads as a means of finding out if there are any dominant users on the bulletin boards.

Conversation Thumbnails (Wattenberg & Millen, 2003) provides an overview of discussions and exploits available metadata to help spotlight potentially interesting sections of the discussion (see Figure 3.22). Each rectangle in the visualisation represents a message, with the indentation depicting thread structure. Colours can be used to depict the perceived value of information, but may also be configured to reflect a range of other metadata. As users choose sections of discussions using a rectangular selector, the full detail of the selected messages is displayed in the message window. When users type new messages, the visualisation searches the forum for previous occurrences of the word being typed, and uses small arrows to highlight all other occurrences of the word in the thumbnail overview.

Figure 3.22: Conversation Thumbnails



Source: Wattenberg & Millen, 2003.

While Conversation Thumbnails gives an overview of the structure of discussions and highlights other messages of potential interest, it suffers from a deficiency similar to that of WebFan, Loom and Conversation Map in that it does not depict the temporal development of threads, failing to show when each message was posted. Furthermore, as was the case with eTree, Conversation Map, Netscan and WebFan, Conversation Thumbnails does not give any indication of which users have posted

which messages, and it is not possible to compare the timeline of threads to see which discussions have been active for longer periods.

3.9 Summary

There is a growing need for techniques and instruments to augment and enhance online communities in order to make them more sustainable and successful. Visualisations are one such technique. They can aid online communities by creating awareness and catalysing social interaction among users, encouraging members to explore and understand the social environment of the online community. Visualisations have the potential to help reduce the amount of time spent searching for information, enabling users to more easily understand and contextualise the activity within online communities, thus reducing the time spent by users in the information-discovery phase. Through the provision of aids to understanding the interaction context, visualisations can act as an enabler to encouraging further contributions within the community.

When developing a visualisation, the key challenges lie in coming up with a suitable metaphor, and ensuring that the visualisation has good usability, making sure that the use of visualisations makes tasks easier and quicker to do. This chapter has considered a range of existing visualisations that have been developed in order to help and support online communities. Matching interest visualisations have been highlighted due to the fact that users of online communities frequently seek to find users and resources of interest during their information-discovery phase. Given that the vibrancy of a community is ultimately dependent upon the conversations that take place between users, visualisations of conversations have also been highlighted, with the primary focus being on bulletin board visualisations given the asynchronous nature of communication that takes place between users of online communities.

However, many of the visualisations discussed in this chapter have common deficiencies. From a usability perspective, Visual Who, Contact Space, Loom and Conversation Map all depict visualisations which can at times be difficult to decipher

as they become crowded, and this may ultimately discourage people from using them.

In the matching interest visualisations discussed in this chapter, FilmFinder visualises potential resources of interest but provides no visualisation of other users with similar interests. Conversely, Visual Who and Community Organiser concentrate on visualising other users, but fail to depict resources of interest in the visualisations. Community Organiser also limits users to declaring their interest in a set of metrics that are predetermined by the system administrator. This means that the system is highly reliant on the administrator augmenting and adding to the categories of interest in a timely fashion in order to reflect the changing needs, interests and requirements of the community's users as and when they may arise.

Turning to the various approaches to visualising conversations, chat visualisations such as Coterie, Chat Circles and Babble, require users to watch live or historical animations of the flow of conversations, and such an approach would not be suitable for visualising asynchronous bulletin board activity due to the fact that this fails to give an easily accessible overall snapshot of the interaction history. ETree shows the overall structure of a large bulletin board with several forums but fails to show the structure of threads within those forums. While WebFan, Loom, Conversation Map and Conversation Thumbnails do depict overall thread structure, they do not show how this structure has developed over time, failing to show when each message was posted. Netscan does show when messages are posted to threads, but only shows one thread at a time, meaning that it is impossible to visually compare the temporal development of multiple threads at the same time.

Visualisations such as eTree, Conversation Map, Conversation Thumbnails, Netscan and WebFan focus on visualising the underlying structures of conversations but fail to show which users posted which messages, meaning that it is not possible to highlight or distinguish messages from the same users within a thread or across a range of threads. Other visualisations such as the timelines in Babble and Conversation Landscapes show exactly when messages are posted and by which

users but due to the synchronous nature of chat rooms, these visualisations would not lend themselves to asynchronous environments such as bulletin boards where it is not uncommon for users to be active participants in several threads at the same time.

PeopleGarden, Newsgroup Crowds and AuthorLines all focus on visualising the activity of users, showing whether they have started threads, or contributed by posting replies. However, this approach means that it is not possible to see the overall structure of threads or how they have developed over time. While it is useful to know that a user may have started a number of threads, it is equally as important to find out if any other users have actually replied to these threads. If there are no replies to a series of threads from the same user, this will send a signal of how the opinions of that user are valued by the rest of the community.

The next chapter builds on lessons learned from previous visualisations. In developing a new set of matching interest and bulletin board visualisations, many of the problems of existing systems highlighted in this chapter will be addressed.

Chapter 4 Experimental Systems

4.1 Introduction

The previous chapter examined the growing body of research into the use of visualisations to aid users of online communities. Much of this existing research has focussed on matching interest and bulletin board visualisations as a means of assisting members of online communities. While the existing systems help provide visual representations of social phenomena, they suffer from a range of shortcomings. The new visualisations presented in this chapter attempt to address these deficiencies, presenting more usable and suitable visualisations that utilise customisable views as a means of providing users with a range of rich visual representations.

As part of this thesis, a range of complementary visualisations for separate matching interest and bulletin board systems have been developed, and these can be altered by users depending upon their specific needs and requirements. This chapter provides an outline of both sets of visualisations and considers them in terms of the hypotheses of this thesis.

4.2 Design Principles

Several of the existing visualisation techniques that were discussed in the previous chapter display the visualisations in a separate window from the main web browser, meaning that users have to switch between different windows. In order to avoid this, both the matching interest and bulletin boards systems outlined in this chapter display the visualisations as an applet on the current page. This approach has been successfully used in Babble (Erickson et al, 2002) and Conversation Thumbnails (Wattenberg & Millen, 2003), meaning that the new visualisations are available to users at all times without having to switch between different windows.

In their research into node link tree diagrams, Plaisant et al (2002) found that different visualisations performed better for different tasks. Furthermore, as discussed during the review of existing visualisation techniques presented in the previous chapter, the use of a single view would not be suitable to present all possible uses that a user may have for a visualisation. Therefore, given that certain visualisations may be more suited to specific circumstances in the online community domain, a range of different visualisations were developed and assessed as a constituent part of both the matching interest and bulletin board systems that are outlined in this chapter. Developing a series of complementary visualisations allows users to view the same data from a range of different perspectives, based upon the user's circumstances and requirements. This enables users to draw more informed conclusions about the efficacy of specific visualisations in helping to complete certain types of task.

The use of standard representations in visualisations avoids introducing spurious or potentially misleading information (Donath et al, 1999). Therefore, in developing both the matching interest and bulletin board systems outlined in this chapter, the visualisations were kept as consistent as possible across each of the representations in order to make them more accessible to users. Furthermore, the design of both sets of visualisations followed the six claims for visually representing group activity in online environments as laid out by Erickson (2003) (see section 3.4).

In both the new matching interest and bulletin board systems that are introduced in this chapter, the web pages of an online community are augmented and enhanced by visualisations. In each case, the visualisations are shown in an applet on the left-hand side of the page, and the visualisations refresh and update depending upon the tasks that users are carrying out. For example, when users are looking for resources of interest, the matching interest visualisation displays a visual representation of the best matches, and when users are browsing the bulletin board, the bulletin board visualisation is displayed, showing an overview of the ongoing conversations.

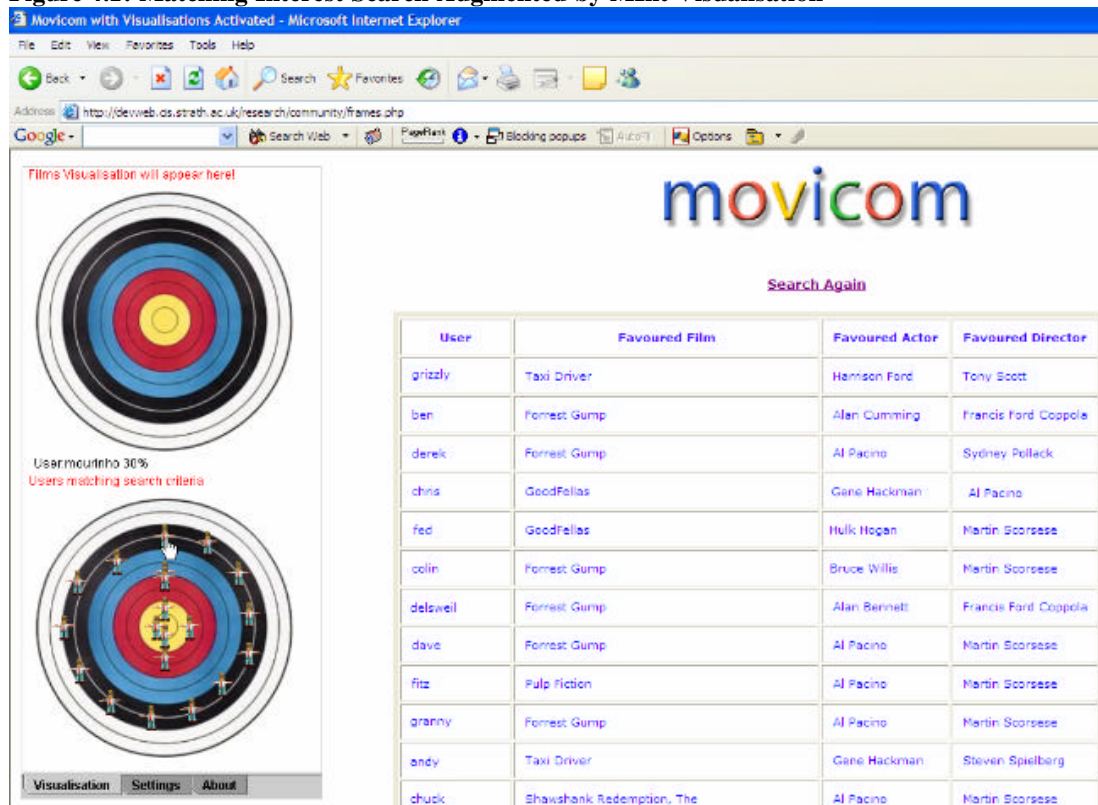
The new visualisation systems each have a set of three different visualisations which can be used for different purposes, providing rich representations and offering different perspectives based on the needs and requirements of users. Both sets of visualisations utilise customisable views that give users full control over the functionality and display of the visualisations. Furthermore, within both sets of visualisations, users can traverse the online community by clicking on different sections of the applets, or by following links on the community's web pages in the standard way. The various features of both the matching interest and bulletin board visualisations will now be considered in more detail.

4.3 Matching Interest Visualisation (MInt)

In developing the matching interest system, influence was drawn from the earlier approaches to matching interest visualisations that were discussed in the previous chapter. Some existing visualisation approaches such as FilmFinder focus on visualising resources of interest while others including Visual Who and Community Organiser focus on visualising other users with similar interests. Furthermore, visualisations such as Visual Who and Community Organiser suffer from screen real estate limitations with several items overlapping, making the visualisations hard to decipher at times. As a result, a new set of matching interest visualisations, named MInt, was developed in order to address these shortcomings, enabling users to visualise both resources of interest and other members with similar interests.

A set of three different visualisations are used to in order give different perspectives on visualising the closeness of match between various users or resources of interest. The provision of a set of complementary visualisations enables users to choose the most appropriate visualisation depending upon their particular requirements. Furthermore, unlike existing visualisations, MInt utilises customisable views as a means of facilitating the visualisation of both resources and users of interest. A sample screenshot of a community search for other members, augmented by the MInt visualisation is shown in Figure 4.1.

Figure 4.1: Matching Interest Search Augmented by MInt Visualisation



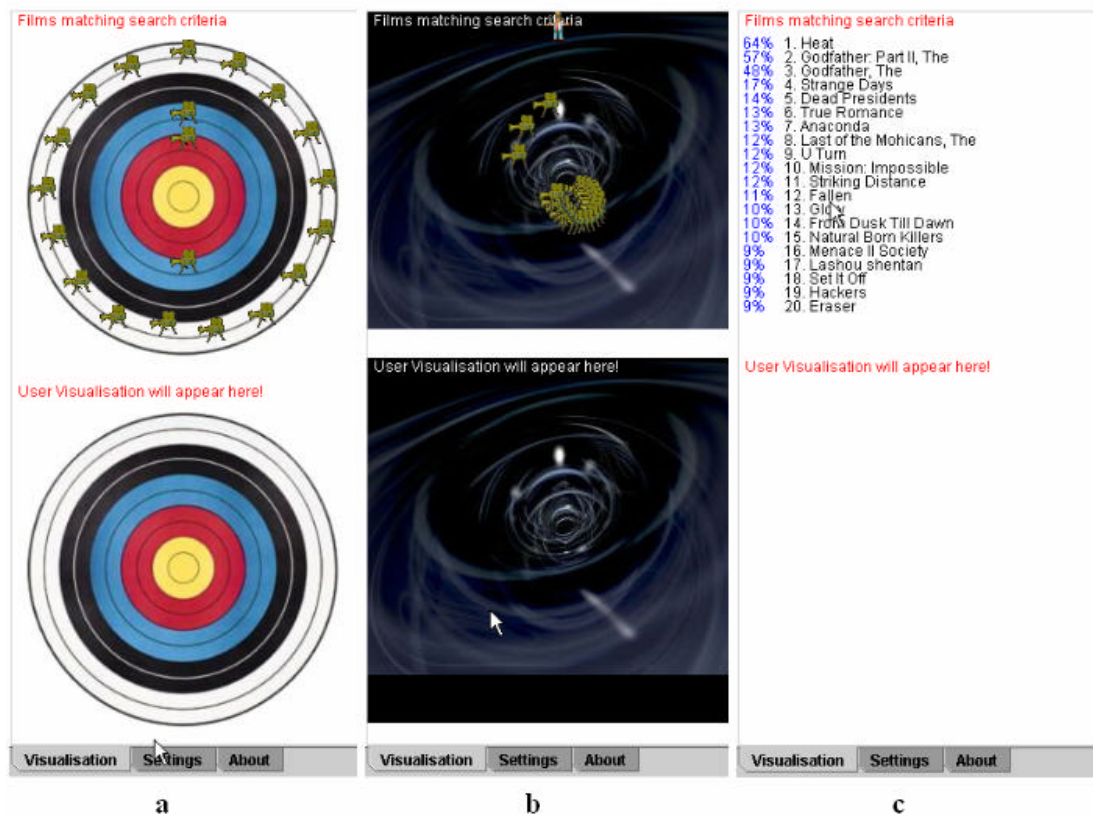
As already outlined, a key differentiating factor between MInt and previous matching interest visualisations is that both resources and users can be shown separately in MInt. When users conduct a search for resources of interest, icons are displayed on the top half of the applet to depict how good a match the items are to the user's profile (see section 4.3.5 for a review of the techniques used to calculate matches). Similarly, when users conduct a search for other users, icons are shown on the bottom half of the applet, displaying how closely their profiles match that of the current user.

In addition to browsing through pages in the normal way, MInt enables users to click on the visualisation applet in order to load a web page that gives further details of a particular user, or resource, of interest. In addition, when users roll their mouse over any of the icons relating to individual users or resources, the name of the particular item is displayed in the middle of the applet, along with a percentage score for how close the item matches the user's profile.

This functionality is common across each of the three different visualisations within MInt. Users are able to get an overview of the distribution of items matching their profile and can instantly view more detail on demand. Across each of the three visualisations, the top twenty matches to the user's search criteria are depicted. But the visualisations each take a different approach to how they actually visualise the data. An example view of the same data shown by the three different visualisation approaches is shown in Figure 4.2. The three visualisations are as follows:

- Dartboard (Figure 4.2a)
- Solar (Figure 4.2b)
- Text (Figure 4.2c)

Figure 4.2: Sample MInt Visualisations



4.3.1 Dartboard

The Dartboard visualisation is split into five coloured bands, each of which represents a quintile. As was the case with Community Organiser (Kamei et al, 2001), the position of each icon in relation to the distance from the centre of the target is relative to the percentage match of the particular item. Icons for individual resources or users are drawn on the appropriate quintile of the Dartboard based upon the percentage match to the user's profile. For example, matches falling between 81% and 100% are drawn in the central yellow band of the Dartboard, while matches between 41% and 60% are displayed in the blue band. The various bands on the Dartboard provide a means for users to immediately compare how close particular resources or users match their own profile.

4.3.2 Solar

Due to the nature of the Dartboard visualisation, space limitations may make it harder to distinguish larger groups of items that are drawn closer to the centre of the visualisation in the yellow quintile. Therefore a refined visualisation was developed to provide a more effective means of visualising stronger matches. The Solar visualisation does this by providing a larger area in which to visualise stronger matches. It draws a spiral of icons to represent how strongly items match the user's profile, attempting to create the illusion of a 3-D landscape with poorer matches appearing to be 'further down' the worm hole, and better matches being shown 'further away' from the worm hole, spiralling out towards the top of the visualisation.

4.3.3 Text

Unlike the previous two approaches to displaying items of interest, which use a visual representation to depict the closeness of matches, the Text representation

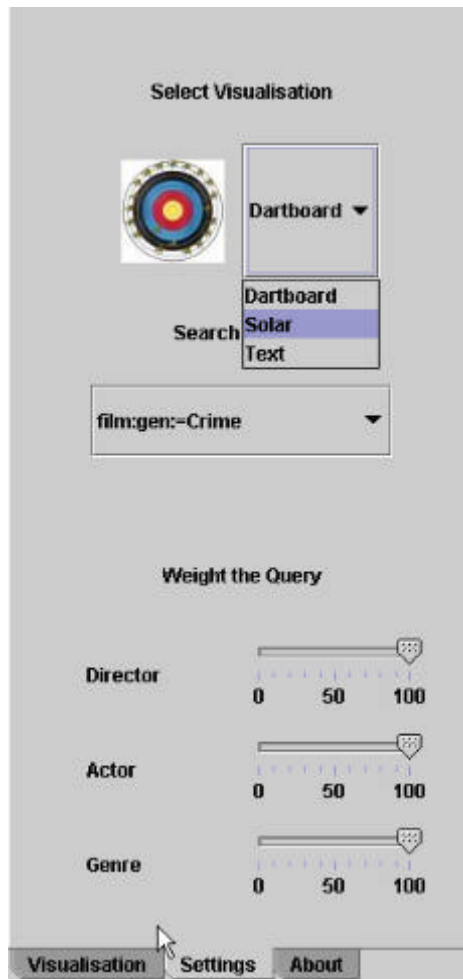
merely ranks the results in the same order as they are shown in the main display. The only augmentation offered by this approach is that a percentage match to the user's profile (see section 4.3.5) is displayed alongside each of the top twenty search results, so that users can get an idea of the distribution of the top twenty matches.

4.3.4 Modifying MInt Settings

When users conduct searches without the aid of the matching interest visualisations, the items are, by default, automatically ranked in order of relevance to the search terms. However, users are also able to sort the results in any way they wish.

Given that the final experiments were carried out within an online community centred on movies (see Chapter 5 for full details of the test bed community and final experiments), users may also wish, for example, to sort the results alphabetically or group different films together by genre. The MInt visualisation provides additional functionality beyond this, allowing users to make modifications via the settings panel (see Figure 4.3).

Figure 4.3: MInt Settings



Users can choose between one of the three different matching interest visualisations, and they can also choose to re-load previous searches. MInt stores details of the previous 20 searches that each user has carried out, and users are free to choose from this list of historical searches. When users choose any of the previous searches from the drop-down menu, this immediately loads the search results into the main page, and users can view the visualisation of these search results by clicking on the visualisation tab in the applet. In addition, users have the functionality to use a range of sliders to weight how terms in their profile are used to rank resources of interest. For example, within the test bed community users may not wish the system to take the genre of films into account when suggesting other users or resources of interest.

4.3.5 Calculation of Similarity Metrics

When users conduct a search for resources or other users, the system returns all documents (i.e. users or resources) matching the search term and the ranking of these search results is determined by their closeness to the user's profile (see section 5.2 for details on the use of user profiles in the experiments). Documents are represented by vectors under the vector space model (Salton, 1971; Salton et al, 1975), and vectors are weighted using the *tf-idf* weighting, which weights terms more highly if they are frequent in relevant documents but infrequent in the collection as a whole.

The *tf-idf* weighting (term frequency-inverse document frequency) is often used in information retrieval (van Rijsbergen, 1979), and is a measure used to evaluate how important a term is to a document in a collection. The importance increases proportionally to the number of times a term appears in the document but is offset by the frequency of the term in the collection. Term frequency, or *tf*, measures assign larger weights to terms that appear more frequently within an individual document. The inverse document frequency, or *idf*, is a measure of the general importance of the term and weights a term according to the inverse of its frequency in the document collection, giving higher value to infrequent or unusual terms: the more documents in which the term appears, the lower the *idf* value it receives.

It is important to note that the novelty of the matching interest visualisations is not reliant upon the similarity measures used to rank items. These similarity metrics are well established and have already been shown to be successful (Salton & Buckley, 1990; Joachims et al, 1997; Salton & Buckley, 1997; Budzik et al, 2000; Budzik et al, 2002; Ruthven & Lalmas, 2003). Furthermore, the ranking of the items (either resources or users) in the main display is the same whether subjects complete the experimental tasks (see section 4.6) with or without the aid of visualisations. The only difference is that the visualisations used to augment the matching interest system provide a visual representation of the distribution of the search results, rather than merely ranking them.

4.3.6 Advantages of MInt Approach

In contrast to existing approaches to matching interest visualisations, MInt makes use of customisable views to enable users to find other users or resources of interest. While the majority of existing approaches focus on either visualising resources of interest or on visualising other members with similar interests, MInt provides a set of visualisations that enables users to do both of these.

Within an online community, users seek to find out general information about the community, looking for items of interest and also for other users with similar interests who they may potentially converse with in the future. The use of MInt means that users can easily visualise whether there are resources, or other users, who closely match their own profile. The ability to configure how the system weights different vectors gives full control to the user, enabling them to find items that are more pertinent. The option to choose from a range of different visualisations also enables MInt to overcome potential screen real estate issues that affect other matching interest visualisations. For example, the provision of the Solar visualisation addresses issues in the Dartboard visualisation that cause groups of particularly strong matches to be drawn in a small area at the centre of the target. Therefore, users have the option to choose the visualisation which they believe will be most appropriate or helpful depending upon the task being undertaken.

4.4 Bulletin Board Visualisation (BulB)

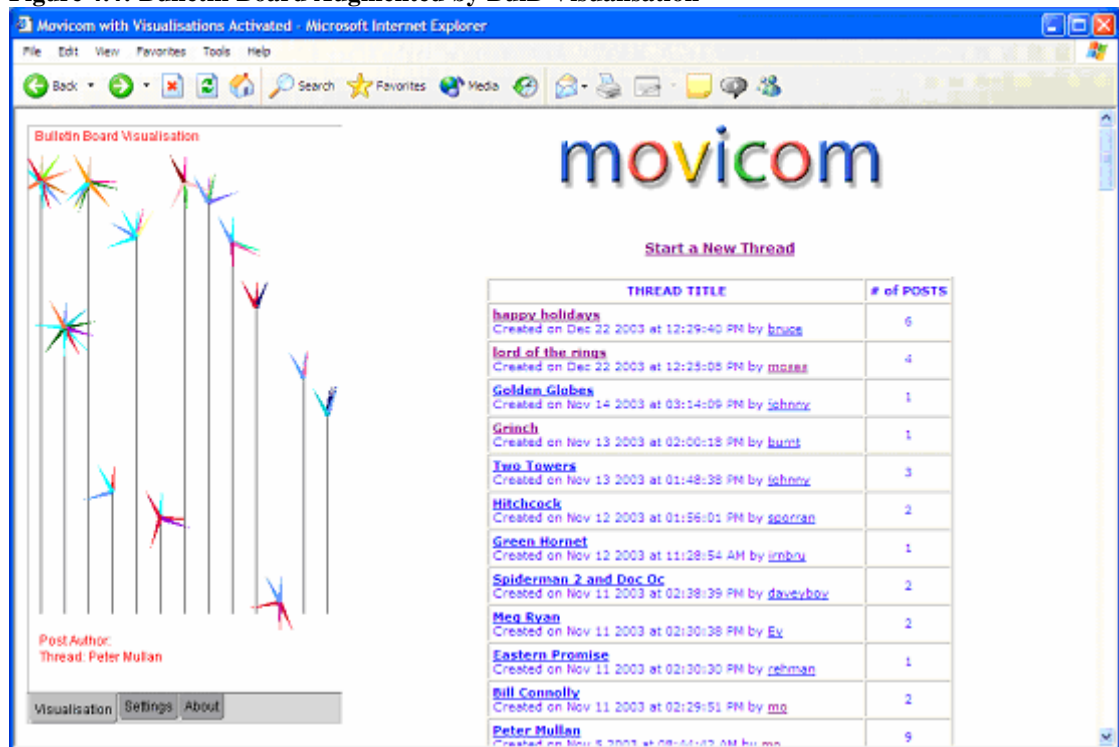
As was the case with the matching interest system, the development of the new bulletin board visualisation builds on, and draws influence from, the earlier approaches to visualising conversations that were discussed in the previous chapter. While some existing visualisations focus on visualising the activity of users, they fail to show overall thread structure or how threads have developed over time. Others

give an overall snapshot of the interaction history, or visualise the underlying structure of threads, but fail to depict which users have posted which messages.

As a result, a new set of bulletin board visualisations, named BulB, was developed in order to address these deficiencies. BulB incorporates much of the functionality of previous approaches that were discussed in section 3.8, and visualises a wide range of information that depicts the milieu, people and activity within conversations in online communities. BulB gives an overview of thread structures and shows the general level of activity within a bulletin board, while enabling users to examine the temporal structure of individual threads and see when messages have been posted by individual users. Again, a customisable, multi-dimensional approach is adopted whereby a set of three different visualisations are used to give different perspectives on visualising the structure of conversations and, unlike existing approaches to visualising conversations, utilises customisable views as a means of facilitating the visualisation of both the structure of threads, and the activity of contributors.

Drawing influence from PeopleGarden (Xiong & Donath, 1999), BulB uses a botanical metaphor and aims to shed light on communication patterns, examining the growth and germination of conversations within bulletin boards. In constructing this visualisation of bulletin board activity, each thread is drawn separately so that users can immediately see the distribution of threads and identify which threads in particular are livelier. This is in contrast to systems such as PeopleGarden that focus on identifying each user separately and fail to show overall thread structure. A sample screenshot of a bulletin board augmented by the BulB visualisation is shown in Figure 4.4.

Figure 4.4: Bulletin Board Augmented by BulB Visualisation



The key features of BulB are:

- A stem, or stalk, to represent each separate thread.
- The height of each stalk represents the total time that each thread has been active, from the first post to the current time. Longer stalks represent threads that have been going longer.
- A unique colour is used to represent each user within the visualisation. This colour is consistent across all threads being visualised.

Encoding data by length or height is useful for making comparisons when a qualitative feel for the data is required (Spence, 2001). Therefore, the height of each stem is used to signify the length of time that each individual thread has been active, with longer stems representing a thread that has been running for a greater period of time. In calculating the height, the length of each stem is scaled against the longest stem being visualised, enabling users to easily compare how long each thread has been active.

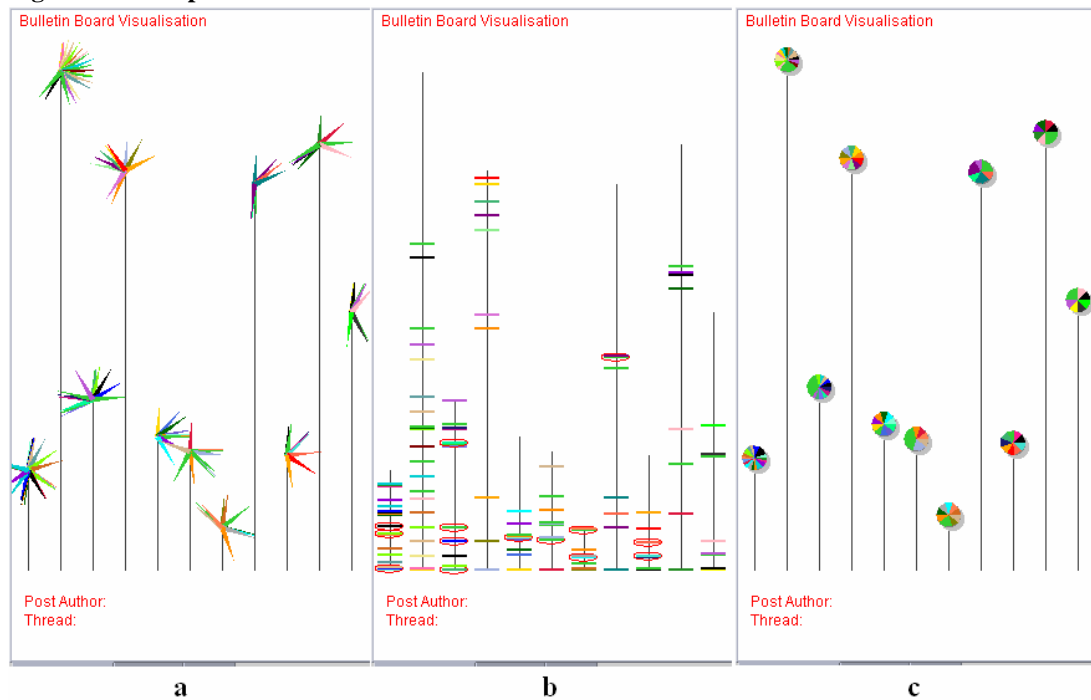
In keeping the colour of each contributor consistent across all threads being visualised, BulB enables users to instantly see which contributors are most active or dominant across all threads. In addition, this allows a user to easily identify the distribution of individual posts in a particular thread and across the visualisation as a whole. It is important to note that the colour of each user within BulB visualisations is not intended to convey any implied meaning. For example, the use of red is not intended to suggest any connotations of anger.

In addition to browsing through the bulletin board in the normal way, BulB enables users to traverse the bulletin board by clicking on the visualisation applet; the webpage for each appropriate thread is loaded on a mouse click. Further, when users roll their mouse over anywhere within the height of each thread, the thread title appears at the bottom of the visualisation panel. Similarly when moving the mouse over the coloured segment for each user, the username of the contributor appears at the foot of the visualisation panel. Through providing this information, it is easier from a user's perspective to compare threads and also examine the activity of particular contributors across threads.

There are three separate visualisations within BulB, each of which visualise the bulletin board in different ways. Across each of the three visualisations, the height of stalks for each thread is the same. The differentiating factor between the visualisations is how the individual posts within each thread are drawn. A view of a bulletin board using the three different visualisation approaches is shown in Figure 4.5. The three visualisations are as follows:

- Temporal thread development a. k. a. Flower (see Figure 4.5a)
- Timeline (see Figure 4.5b)
- User thread participation a. k. a. Pie (see Figure 4.5c)

Figure 4.5: Sample BulB Visualisations



4.4.1 Flower

In this visualisation, the stalk-head is used to show the development of the thread since it started. Segments are drawn to signify each new post with livelier threads having more segments. The stalk-head circumference is scaled to represent the timeline of every thread. Each segment in the head is drawn clockwise around the circumference. The first post in each thread is always drawn at 12 o'clock on the clock face and the position of each subsequent post around the circumference is based on the time the message was posted in relation to the length of time that the thread has been active.

Figure 4.6: Scaling of Posts in 'Flower' Visualisation



To illustrate this point, Figure 4.6 shows a small thread with three posts, each contributed by three different users. Given that there has been a week since this thread was started, it can be seen that the first reply to the initial post was not made until midway through the fifth day, and the final post in the thread was made a day ago - six days after the thread was started.

In comparing how threads have developed over time, users can examine the distribution of posts at the stalk-head to see when posts have been made and by whom. This allows the comparison of the temporal development of threads by looking across all the threads shown in the visualisation.

4.4.2 Timeline

Whereas the first visualisation draws posts at the top of the thread, the Timeline distributes posts along the height of each thread stalk. As previously discussed, the height of the stalk represents the length of time that the thread has been active, and in this particular visualisation each post is drawn as an echelon along the stalk, and the position of the post on the Timeline is based upon when the post was made in relation to the length of time that the thread has been active. Using a similar principle to that already used in Conversation Landscapes (Viegas & Donath, 1999), the first post is always drawn at the root of the stalk, and subsequent posts are drawn as echelons along the scale of the stem to depict when the message was posted. This approach to drawing individual posts on the visualisation means that there is more space in which to show when each message was posted.

There is however a refinement in the way that messages are depicted in this visualisation compared to the first approach. In the Flower visualisation, if there is a flurry of activity with several messages being posted at the one time, it may be difficult for users to discern this due to the fact that messages may be drawn on top of each other at the top of the thread. Although the Timeline distributes posts along the height of each thread stalk, there may still be circumstances in which posts may overlap each other, such that one echelon is drawn on top of another in the

visualisation. Therefore a refinement was introduced in the form of a red oval, or hotspot, which is drawn around the echelon in order to indicate that there is more than one posting at this point in the Timeline.

Figure 4.7: Flurry of Posts in the ‘Timeline’ Visualisation

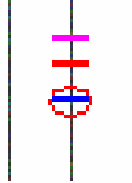


Figure 4.7 shows an extract of a Timeline visualisation with three threads, the middle of which has a small flurry of activity within the short period of time illustrated. There are a total of 4 posts shown, with the hotspot depicting that there are 2 posts close to each other and which are overlapping on the visualisation.

Although this example indicates a hotspot around two contemporaneous posts, it may be that there are more than 2 posts close to each other. In this case, there would be no difference in the appearance of the visualisation to the user – one echelon would be surrounded by a single red oval. Alternative depictions for such circumstances were tested with users during the development of the visualisations. However, these were discarded after feedback showed that alternative ways of visualising areas with more than three contemporaneous posts were proving confusing to the users.

4.4.3 Pie

Unlike the previous two BulB visualisations, where individual posts are depicted, the third visualisation draws a pie chart as a stalk-head. The Pie visualises the proportion of posts in each thread that are contributed by each user, thus enabling users to discern more easily whether threads are being dominated by specific contributors. Each slice of the pie chart represents the percentage of each thread made up by a particular user's posts.

Figure 4.8: Spread of Users in ‘Pie’ Visualisation

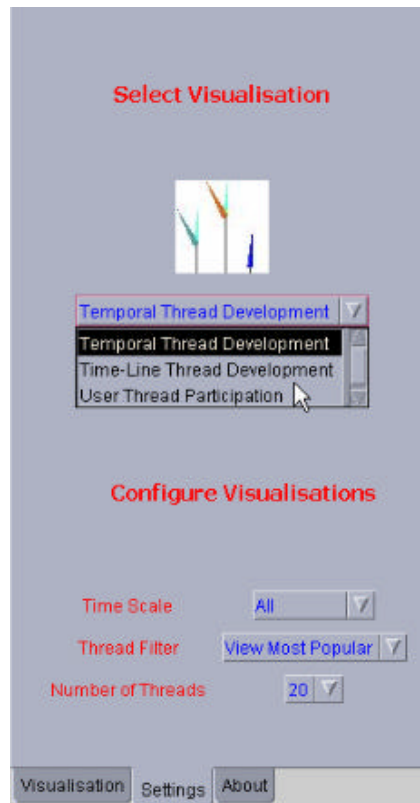


The visualisation extract in Figure 4.8 shows a set of 3 threads. All three threads have been active for a similar amount of time given that all the stalk-heads are at the same height in the extract shown. Thread ‘a’ has a single post from one contributor, thread ‘b’ shows a thread with one dominant contributor, while thread ‘c’ depicts a more even spread of users. Through examining the Pies at the top of each stalk, users can get an idea of the distribution of contributors across all the threads being visualised.

4.4.4 Modifying BulB Settings

As with most standard bulletin boards, the non-visually-enabled bulletin board system used allows users to search through the archive in order to filter threads by their content or by participants. If users conduct a search of this nature on the bulletin board archive, a visualisation of the filtered search results is shown in BulB. The BulB visualisations, which augment the existing bulletin board system, provide additional functionality beyond this through the use of a settings panel that enables users to get different views of the bulletin board activity (see Figure 4.9).

Figure 4.9: BulB Settings



As already discussed, users can choose between one of three different visualisations depending upon their circumstances and preferences. In addition, users can customise BulB and get different views of the bulletin board activity by altering various options within the settings panel. They can change the way that threads are filtered, opting to display the most popular threads with most posts over a given time period, or visualise those threads which have most recently had posts. Users can also filter each view by time-scale, ranging from the past 24 hours through to the entire lifespan of the bulletin board. For example, this then enables users to visualise information such as the most active threads over the last week. The final setting includes the ability to filter the number of threads that are drawn within the visualisation at any time. For example, users may wish to visualise only the five most popular threads within the bulletin board at any time. All of these settings can be combined to give customisable visualisations depending upon the user's requirements.

4.4.5 Advantages of BulB Approach

Unlike existing approaches to bulletin board visualisation interfaces, BulB adopts customisable views as a means of enabling users to assess current levels of activity across threads, and observe the growth of conversations. While existing visualisation approaches either focus on visualising the structure of threads, or on the activity of contributors, BulB enables users to do both of these things.

In standard text-based bulletin boards, users would need to examine the date and time of individual posts in order to get a picture of activity within threads. With the aid of BulB visualisations, users are able to easily compare the level of activity, both historically and currently active, across a range of threads at a glance. BulB gives an easily accessible snapshot of the overall interaction history, enabling users to immediately get a picture of how threads have developed over time and identify which users have been most dominant. The ability to choose the type of visualisation, and filter how data is displayed, gives full control to the user, allowing them to configure exactly what is displayed and providing the option to either display threads with the most messages, or threads which have most recently had posts. The use of customisable settings enables users to identify the activity and level of contribution of various users within the context of the bulletin board as a whole, and also within filtered sections of the bulletin board where appropriate.

Users can examine the activity of individual contributors to the bulletin board by looking for the reoccurrence of common colours across threads in the visualisations, observing the number of users posting messages in and across threads, and observing whether any users are active participants in multiple concurrent threads. This approach enables the assessment of the overall interaction context, gaining an overall picture of posting patterns and identifying prolific posters within the bulletin board. The Pie visualisation can also be used to show what percentage of each thread is made up by individual contributors so that the frequency of their posts can be identified. Given that posts from the same user are grouped together in a Pie, users

can easily spot if there is an even distribution of contributors in a particular thread, or whether there are dominant users.

BulB also enables users to immediately get an overview of the overall structure of the bulletin board, allowing them to compare multiple threads, observe when individual message were posted, and see how multiple threads have developed over time. It is easy to see which threads have been active longest through studying the length of each stalk, and the placement of each post in the visualisations shows how threads have developed over time so that the number and distribution of posts in a thread can be easily identified. Thus, a fading or stagnant group, with only a few participants still posting the occasional message, resembles an overgrown garden with tall scraggly plants which have no new buds. Conversely, a lively group is depicted by a thriving and varied garden with tall plants, short plants, lush flowers and new buds.

4.5 Hypotheses

Existing research has shown online communities can be augmented through the through the use of visualisations. However, much of this research fails to examine the efficacy of these visualisations in helping users complete tasks that they would be likely to undertake in their use of online communities.

This chapter has introduced new matching interest and bulletin board systems, both of which are augmented by a range of visualisations that improve on existing visualisation techniques. Both sets of visualisations are now assessed in the coming chapters as a means of testing their efficacy in not only helping users complete tasks, but also in reducing the amount of time spent during the information-discovery phase. This thesis seeks to test the hypothesis that, for simple tasks conducted during the information-discovery phase, visualisations help users achieve more accurate results. Furthermore, this thesis tests the hypothesis that visualisations help users complete these tasks in a more efficient manner. The hypothesis that specific

visualisations are more helpful in completing certain tasks is also tested. The null hypotheses for each of these can be stated as follows:

Hypothesis 1

H₀: Visualisations do not help users of online communities find more accurate information in simple information-discovery tasks

Hypothesis 2

H₀: Visualisations do not help users of online communities to complete information-discovery tasks in a more efficient manner

Hypothesis 3

H₀: No particular visualisation is any more helpful in conducting simple information-discovery tasks

The first hypothesis tests whether the use of visualisations helps users achieve more accurate results for tasks that they would be likely to conduct during the information-discovery phase. More information on the type and range of tasks that users were asked to complete as part of the experiments is discussed in section 4.6.

The second hypothesis tests whether visualisations help users complete tasks in a more efficient manner. This hypothesis examines whether users can complete simple tasks quicker, and with less mouse clicks, using the visualisations.

In addition to examining whether visualisations help users complete tasks in a more efficient manner, it is also important to investigate which visualisations, if any, are more helpful in completing these tasks. Given that a range of visualisations are used to augment both the matching interest and bulletin board systems introduced in this chapter, the third hypothesis seeks to test whether any individual visualisations are more helpful to users in completing specific tasks.

4.6 Tasks

Having considered the three hypotheses that are tested within this thesis, it is important to now consider the type of tasks that users were asked to complete as part of the experimental analysis of both the visualisation systems. For each of the matching interest and bulletin board systems, users were asked to complete four different types of task, and these will now be considered separately for each system.

The tasks that are used in testing the matching interest and bulletin board visualisations are not intended to be exhaustive. But they do provide a representative sample of the type of tasks that users may be likely to undertake in an online community setting. The tasks are based upon the taxonomy of user objectives that was introduced in section 2.7, and are representative of the type of tasks normally carried out by users of online communities as outlined by Preece (2000) and Warms et al (2000b). A range of different tasks are used in the experiments as a means of testing the effectiveness of the visualisations in helping users in a variety of scenarios.

4.6.1 Matching Interest

The hypotheses outlined in section 4.5 test the efficacy of the various matching interest visualisations in helping users find other users or resources of interest. Given that users often seek to get an overview of the offering and content of the community as part of their information-discovery phase, looking for resources of interest and trying to find information about other members of the community, it is important that any matching interest visualisations enable users to establish whether the interests of the community match their own interests.

As discussed in section 3.7, matching interest visualisations should convey information about an online community and its members, helping users to find resource of interest and also connect with like-minded members. Therefore, a set of four different tasks were chosen in order to test the efficacy of the visualisations in

not only visualising resources or users of interest, but also in representing different distributions of results. Out of the four different tasks, two ask users to find resources of interest, while the other two involve searching for other users. The tasks also test the efficacy of the visualisations in providing meaningful support to users in scenarios where the results are distributed as follows:

- One clear strong match followed by a cluster of results
- A set of clear strong matches
- A set of weaker matches
- A handful of weak results

In addition to testing whether the visualisations assist in searching for a range of users or resources of interest, it is also important to test the effectiveness of the visualisations in presenting widely differing distributions of results. The success of the visualisations in providing meaningful representations of different distributions of results will provide a significant test of their applicability to a range of different scenarios.

4.6.2 Bulletin Board

Given that the bulletin board visualisations are likely to be used in a wide range of circumstances, it is important to consider whether any specific visualisations are more helpful to users in completing certain tasks. As discussed in section 3.8, visualisation can be used to represent a rich amount of information surrounding the interactions that take place within online conversations. Therefore, as was the case with the matching interest system, a set of four different tasks were chosen. These tasks represent some of the common information-discovery tasks which users of bulletin boards may be likely to undertake. The tasks are as follows:

- Identify dominant posters
- Identify the most popular recently active threads
- Identify threads which are becoming stagnant

- Identify longest running threads which have recently been active

As outlined in Chapter 2 and Chapter 3, before users become more active participants in the community, through contributing and interacting with other members, they take a more passive role at first as they seek to discover information. As part of this process, they look for the key topics of conversation and seek to find out who the core members are that make most contributions. The tasks that form part of the experiments address these areas. They also provide a means of testing whether visualisations are effective in helping users in a range of different scenarios that they are likely to face during their use of online communities.

4.7 Summary

This chapter has introduced new sets of matching interest and bulletin board visualisations. These new approaches provide customisable views, presenting more usable and suitable systems that address various deficiencies of existing visualisations. The provision of a range of complementary visualisations in both the matching interest and bulletin board systems provides rich representations and enables users to choose the most appropriate visualisation depending upon their particular requirements and circumstances.

The three hypotheses of this thesis have been discussed, along with an overview of the various tasks which test subjects were asked to undertake as part of the user experiments. The methodology behind these experiments is examined in detail in Chapter 5, while the results of the experiments can be found in Chapter 6.

Chapter 5 Experimental Methodology

5.1 Introduction

This chapter outlines the methodology used in testing the experimental systems. The pilot test is outlined before presenting a more detailed examination of the methodology behind the main experiments.

5.2 Experimental Domain

A test bed community was launched with the sole purpose of testing the experimental hypotheses. In determining the domain of the test bed community, movies were chosen with the aim of appealing to as broad a spectrum of potential experimental subjects as possible, and a data set from the Internet Movie Database¹³ (IMDb) was used to populate the community. The use of the IMDb data set provided the base for testing both the matching interest and bulletin board visualisations, enabling the underlying database to be populated with several thousand films. The IMDb data set provided a rich base for use in the experiments, consisting of 13,285 films, with 7,219 directors and 31,257 actors across a range of 19 different film genres.

The use of this data set meant that a snapshot of real community data could be presented to users. Using the data under experimental conditions also reduced extraneous factors which may have impacted upon the experiments had an active online community been used.

To augment the underlying data set, and to compensate for the lack of underlying historical interaction data, test subjects were invited to set up user profiles in advance of the user experiments. As part of this process, they chose a range of favourite films, actors, directors and genres from the underlying data set. This meant that each participant had a rich profile set up in advance of the final user experiments, and this

¹³ <http://www.imdb.com>

user profile was used as the basis for suggesting potential films of interest to the test subjects as part of the testing of the matching interest visualisations. Profiles were also generated for ‘dummy’ users as a means of establishing an extensive user database which could be used to allow test subjects to find other users with similar interests.

When carrying out the individual experimental tasks, users were allowed to freely browse and search the test bed community. However, they were not permitted to use any external sites (e.g. Google¹⁴, IMDb etc). These were deemed as replacements for the community being used and their use was prohibited. Subjects were allowed to search within individual community web pages using Internet Explorer’s ‘Find’ function, and several users used this functionality to locate areas of interest within a particular page.

5.3 Pilot Testing

Prior to testing getting underway, the experimental protocol was given full approval by the ethics committee within the Department of Computer and Information Sciences (CIS) at the University of Strathclyde. Following approval, a pilot test was conducted in order to debug the questionnaires and search tasks used in the experiment. At this stage, five volunteers from within the Computer and Information Sciences (CIS) Department at the University of Strathclyde were each asked to carry out a full test session.

No time limits were imposed on users in completing the tasks, and as a result of feedback from users and through analysis of the time taken to complete each individual task¹⁵, it was decided to impose a nominal time limit of four minutes per task during the final experiments. This was deemed sufficient time to complete the tasks due to their simple and relatively straightforward nature.

¹⁴ <http://www.google.com>

¹⁵ No user took more than three minutes to complete any individual task during the pilot testing.

A further outcome of the pilot testing was that some questions had to be re-worded in order to improve their clarity and reduce any ambiguity. However, there were no changes to the overall structure of the experiment, or the nature of the tasks therein, and there were no technical errors which may have impeded data collection.

As with the main experiment, users were required to carry out four tasks using visualisations and four tasks without the aid of visualisations. This applied to both the matching interest and bulletin board systems.

5.4 Test Conditions

The test conditions and equipment were identical for each user. The experimental subject carried out the tests on a desktop machine and their test session was recorded using the Camtasia¹⁶ screen capture package.

Dividing screens were placed at either side of the experimental location in order to minimise any external noise or distractions. Users were observed throughout their test session, and log files were used to store the number of mouse clicks and length of time taken to complete each individual task question.

Observing the users also allowed any interventions had there been any technical problems with the experimental system. However, this was never required. Users were provided with no help in completing the tasks.

5.5 Test Subjects

The test subjects were mainly staff and current and former students at the University of Strathclyde. In total, twenty subjects were recruited for the main experiment. This was done by sending out e-mails to the staff and student mailing lists within the Department of Computer and Information Sciences at the University of Strathclyde.

¹⁶ Camtasia records a video of all activity on the screen, allowing the test session to be saved as an avi and played back at a later date.

There were only twenty-one responses to the call for volunteers and the final response came after all the test sessions had already been timetabled. Therefore, the final volunteer was not selected to take part in the study.

Had there been additional volunteers, it may have been possible to pre-select twenty test subjects and split the volunteers into two equal groups; those who were frequent visitors to online communities, and those who were not. This would have enabled testing of the attitude and performance of users based upon their previous experience in using online communities. However, due to the limited number of volunteers, it was not possible to split the volunteers into groups in this manner.

Subjects were not paid for their participation in the experiment. They were, however, given the opportunity to take part in a prize draw where prizes included £10 and National Lottery scratchcards.

5.6 Repeated Measures Design

The aim of the experiments was to test the usefulness of visualisations within online communities. As a means of controlling against other variables which may impact the results of the testing, the same users carried out tasks both with and without the use of the visualisations. In using this repeated measures design, the users performed under both conditions of the experiment, thus balancing out the effects of subject variables (Miller, 1984; Robson, 1990). Therefore any differences in the results of the testing should not be contaminated by the disposition of individual users.

5.7 Task Order

As a further control to protect against any order effects such as learning curves and fatigue or boredom, the order in which sections of the experiment were carried out was counterbalanced across users. In order to reduce confounding, the experiment

was designed to reduce the likelihood that the use of one system, or attempting one type of task, may influence the next task-system variation.

Table 5.1 shows the Latin Square design that was used in order to rotate the order of the experimental systems. The factors in the table are the matching interest (MI) and bulletin board (BB) systems, and whether the task were completed with (vis) or without (nonvis) the aid of visualisation. Furthermore, the order in which users attempted individual task questions within each section of the test was randomised across test sessions using a similar Latin Square design.

Table 5.1: Latin Square Experimental Block Design

Test Subject	System Order			
	1	2	3	4
1	MI _{vis}	MI _{nonvis}	BB _{vis}	BB _{nonvis}
2	MI _{nonvis}	BB _{vis}	BB _{nonvis}	MI _{vis}
3	BB _{vis}	BB _{nonvis}	MI _{vis}	MI _{nonvis}
4	BB _{nonvis}	MI _{vis}	MI _{nonvis}	BB _{vis}

5.8 Experimental Procedure

Each subject was asked to attempt identical tasks. Although the details of the matching interest tasks were determined by the profile that users provided in advance of the tasks, the distribution of results, and the structure and wording of the tasks was identical across all users.

The order in which tasks were presented to the user, and the order in which systems were used, was determined by the Latin Square experimental design that was outlined in the previous section. The time taken to complete the experiment varied between forty-five and one hundred minutes, dependent upon the time that users took to complete each task and fill in the questionnaires. Each test subject was provided with light refreshments and was given the opportunity of a five minute break between using each system. Incorporating time for breaks between each segment of the experiment, the majority of users completed the experiment in under sixty-five minutes.

For each experimental session, the following steps were followed:

1. Users were welcomed and asked to read the experimental procedures and instructions (see Appendix A)
2. Users were then invited to sign and date the experimental procedure and instructions.
3. Users were asked to complete a pre-test questionnaire (see Appendix B). This provided details of their education, previous Internet use, previous experience in using online communities, and their level of interest in the experimental domain (movies).
4. Users were given a tutorial on the experimental system, followed by a training task on that system (see section 5.9). The training tasks were identical for every user and gave them the opportunity to familiarise themselves with the idiosyncrasies of the experimental systems. Users were free to ask as many questions as they wanted about the system at this stage.
5. Once users were happy with the system, they were given the first task to do. No further assistance or guidance was given to users from this point onwards. Users were given a time limit of four minutes to complete each individual task¹⁷.
6. After completing each individual task, users were asked to complete a task questionnaire (see Appendix C).
7. Steps 5 & 6 were repeated for an individual system until the users had carried out four tasks with the aid of visualisations and four tasks without visualisations for that particular system.
8. Having completed all eight tasks for a particular system, users were asked to complete a post-system questionnaire (see Appendix D).
9. Subjects were offered a five minute break before repeating steps 4-8 on the next experimental system.

¹⁷ Users were not provided with a clock or timer, but were given an oral warning when there were thirty seconds remaining. None of the users taking part in the study used the whole four minute time limit for any of the questions.

5.9 System Orientation

Prior to attempting their tasks, users were given a demonstration of how each system worked. This enabled users to familiarise themselves with the use of the community site and accompanying visualisations. They were also given the opportunity to practice using the systems with the aid of practice tasks (Rubin, 1994). The pre-task training lasted up to a maximum 15 minutes for each of the bulletin board and matching interest systems. An overview of the orientation process is as follows:

- Users were given a demonstration of how to browse the test bed community and shown the functionality of the visualisations including the visualisation settings panel.
- Users were given a training task to carry out, and were given the opportunity to explore the functionality and settings of the various visualisations. This allowed users to familiarise themselves with the systems.
- The training session stopped once users indicated that they were completely happy and comfortable using the system.

Users were able to make comments or ask questions at any time during the training session. Despite being allocated 15 minutes to familiarise themselves with the system, none of the 20 users used the full allocation of time and they all indicated their willingness to get underway with the testing before the allocated time had elapsed.

5.10 Questionnaires

Questionnaires were used as the primary method of getting user feedback during the experiments. There were three types of questionnaires used in the experiments: pre-test, task, and post-test. These questionnaires are included in the appendices and contain four main types of question; check-box questions, Likert scales, semantic differentials and open-ended questions. Each type of question used will now be examined in more detail.

5.10.1 Check-box Questions

Check-box questions (Figure 5.1) were used in the pre-test questionnaire to help categorise users into groups. These questions asked users to choose from a pre-selected list of options.

Figure 5.1: Sample Check-Box Question

How often do you visit these Online Communities?

once or twice a year	once or twice a month	once or twice a week	once or twice a day	more often
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5.10.2 Likert Scales

Likert scales present users with a statement and they are asked to register their level of agreement or disagreement with the statement. A five-point scale was used and the score was listed at the base of the scale (Figure 5.2). Throughout the experiment, the positive and negative ends of the scale were reversed in consecutive questions in order to ensure that users were paying full attention and reading each question as they proceeded through the questionnaires.

Figure 5.2: Sample Likert Scale Question

It was easy to *learn to use* the visualisations

Agree				Disagree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	4	3	2	1

5.10.3 Semantic Differentials

Semantic differentials use pairs of words at opposite ends of a scale and they are used to identify and evaluate a user's attitude towards a particular statement. Users were asked to fill in a check-box on each row to indicate their attitude towards each pair of words (Figure 5.3). The arrangement of positive (e.g., 'reliable', 'attractive') and negative (e.g., 'unreliable', 'unattractive') descriptors were randomised in order to ensure that subjects paid due care and attention when completing the differentials (Busha and Harter, 1980).

Figure 5.3: Sample Semantic Differentials Question

The matching interest visualisations were:

	1	2	3	4	5	
simple	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	complex
unreliable	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	reliable
interesting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	boring
unattractive	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	attractive
informative	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	uninformative
relevant	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	irrelevant

5.10.4 Open-ended Questions

Users were also given the opportunity to fill in responses to open-ended questions, without the need to make a selection from a range of pre-determined responses. These open-ended questions were optional but were useful in terms of eliciting information about the system, individual tasks or the experiment in general.

5.11 Summary

This chapter has outlined the methodology used in carrying out the user experiments. The next chapter examines the results of these experiments for both the matching interest and bulletin board visualisations.

Chapter 6 Experimental Results and Analysis

6.1 Introduction

This chapter presents the results of the user experiments that were outlined in the preceding two chapters. The experiments test the efficacy of both the matching interest and bulletin board visualisations, examining whether the visualisations help users in completing each task. In addition, the experiments examine whether any specific visualisation is more useful in helping users complete each task.

6.2 Overview

A total of twenty subjects, with different levels of experience in using online communities, took part in the experiments. Results are presented for the subjects across a range of visualisations. For all experiments carried out, statistical tests were carried out at $p < .05$ unless otherwise stated. For each statistical test, the distribution of the data was first analysed to decide whether a parametric or non-parametric test should be carried out.

The results presented in this chapter are based upon system logs and questionnaire responses from the experimental sessions. As outlined in Chapter 5, the questionnaires included five-point Likert scales and semantic differentials. Given that the arrangement of the positive and negative descriptors in the semantic differentials was randomised, this meant that positive descriptors were sometimes represented by a high score (i.e. 5), and sometimes by a low score (i.e. 1). This ensured that the subjects applied due care and attention when completing the differentials (Busha and Harter, 1980). During the statistical analysis, the scales were reversed, where appropriate, to ensure that positive descriptors were represented by high scores in all cases.

6.3 Subject Demographics and Online Experience

At the start of each experimental session, users were asked to complete a pre-test questionnaire (see Appendix B). The average age of the test subjects was 32.05 years (minimum 19, maximum 56, standard deviation = 10.66 years). 85% of the test subjects were current students, researchers or academics within the Department of Computer and Information Sciences at the University of Strathclyde. On average, subjects had been using the Internet for 10.4 years (minimum 3, maximum 15, standard deviation = 2.85 years).

95% of the subjects stated that they were members of online communities, with 65 % visiting two or more communities on a regular basis. 45% of the subjects were frequent visitors to online communities, visiting at least once or twice per day. Despite the high percentage of subjects being members of online communities, only 45 % considered themselves to be active members of these communities.

The majority of test subjects (70%) stated that they used online communities as a social medium. 40% of subjects used online communities for educational purposes, while 30% used them for work.

Subjects were also asked to indicate their general experience in using online communities by completing a set of semantic differentials. They were asked to evaluate their previous experience in using online communities, based upon how 'favourable'/'unfavourable', 'relaxing'/'stressful', 'interesting'/'boring', 'educational'/'facile' and 'satisfying'/'frustrating' they found them. Table 6.1 shows the subjects' attitude towards the pairs of descriptors on a five-point scale, with positive descriptors represented by a high score. The table presents the median and interquartile range (IQR), along with the minimum and maximum scores for each of the semantic differential pairs and the overall differential score.

Table 6.1: Previous Experience in Using Online Communities

Differential	Median	IQR	Min	Max
Favourable	4.0	1.00	3	5
Relaxing	4.0	1.00	1	5
Interesting	4.5	1.00	3	5
Educational	3.5	1.00	2	5
Satisfying	4.0	2.00	2	5
<i>Overall</i>	<i>19.5</i>	<i>4.00</i>	<i>14</i>	<i>24</i>

Overall, users had a positive attitude towards their previous experience in using online communities. None of the users responded that they had ‘unfavourable’ or ‘boring’ encounters, indicating that users were generally positive about their prior use of online communities. Although online communities were rated as being more educational than not, some users did indicate that their previous experience had been facile.

The largest variations in scores came when users were asked to indicate whether online communities were ‘relaxing’/‘stressful’, and ‘satisfying’/‘frustrating’. This suggests that, despite having an overall favourable view of their previous encounters, some users had previously found communities to be less straightforward to use than they would have liked.

6.4 Users’ Attitude towards Experimental Domain

Since the test-bed community was based around movies, it was important to gauge the subjects’ interest in the experimental domain. 90% of the users indicated an interest in movies. On a 5-point Likert scale, the median value given by users was 4 (minimum 2, maximum 5, IQR = 1). This strong interest in movies within the test subjects was reinforced by the fact that 90% of the users indicated that they watched movies at least once or twice a week, or more often.

As part of the experiment, users were asked to carry out tasks on the matching interest system based upon the profile which they had set up in advance of the test.

Therefore it was important to determine whether this profile accurately matched their specific tastes. All 20 subjects believed that the profile they established in advance was an accurate depiction of their taste in movies. On a 5-point Likert scale, the median score was 4 (minimum 3, maximum 5, IQR=1).

6.5 Data Analysis and Statistical Testing

As outlined in Chapter 4, users were asked to carry out four types of task for each of the bulletin board and matching interest systems. Given that these tasks were carried out both with and without the use of visualisations, this meant that there were a total of 16 tasks to be completed by each user (see Appendix C).

For each question, users were asked to carry out a task and make a note of the three best matches. In addition to a user's score in completing each task, the time taken and the number of mouse clicks used to complete each question was recorded. This data was supplemented by a questionnaire that users completed after each question. For each question, users were asked to complete a range of five-point Likert scales.

The data from each user was grouped into pairs, examining their performance in each task both with and without the use of visualisations. To test if the population means (or medians, where appropriate) of the two groups (with and without visualisations) are the same, the paired data was subtracted and the differences analysed. For each of the tasks carried out by users across both systems, the distribution of the data sets of the paired differences was not found to be normal. Therefore, non-parametric tests, namely Wilcoxon signed rank tests, were conducted throughout. The Wilcoxon signed ranks test is a more powerful test than a simple sign test since in addition to considering the direction of the differences between pairs, it also considers the relative magnitude of the differences, giving more weight to a pair which shows a large difference (Siegel & Castellan Jr., 1988).

The null hypothesis of the Wilcoxon signed rank test is that the mean difference between the paired samples (visualisation and non-visualisation) is zero and has a

symmetrical distribution about zero. This hypothesis was tested across all tasks for both systems.

For each task carried out with the aid of visualisations, users had the opportunity to use three different visualisations for both the matching interest and bulletin board systems. As part of the questionnaire for each task that was completed with the aid of visualisations, users were asked to rate the usefulness of each of the three different visualisations on a five-point Likert scale.

Given that Likert scales are ordinal in nature, and that the distribution of the data was not found to be normal, non-parametric statistical tests were carried out. In order to investigate whether any specific visualisation was more helpful than the others in completing specific tasks, the Friedman two-way analysis of variance by ranks test for k related samples was conducted. This tests the null hypothesis that the 3 measures have been drawn from the same population with the same median. If the alternative hypothesis is true, then at least one of the visualisations has a different median. i.e. at least one of the visualisations was favoured more highly by the users in completing the task.

In cases where the Friedman test gives a statistically significant result, further analysis was carried out to discover the source of the difference. This was done by carrying out Wilcoxon signed ranks tests on pairs of the visualisations. The visualisations were paired together in turn and the difference between the pairs was analysed.

6.6 Matching Interest System

The matching interest tasks examine whether the presentation of visualisations aids users in completing simple search tasks within an online community context.

6.6.1 Performance across All Scenarios

Before examining the results for individual tasks, the data across all the matching interest tasks as a whole will be discussed. As already discussed, all statistical tests were carried out at the $p < .05$ level of significance.

Table 6.2 outlines users' scores in completing each task (out of 3), the time taken to complete each task (with a time limit of 240 seconds), and the number of mouse clicks used in completing each task. The table presents the median and IQR both with and without visualisations, along with Z statistics and p values.

Table 6.2: Wilcoxon Signed Ranks Test for MInt Data (all Tasks)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Score	3.0	1.00	3.0	0.00	-5.822 ⁱ	<0.0005
Time	44.0	38.50	27.5	20.75	-6.251 ⁱⁱ	<0.0005
Clicks	5.0	4.00	3.0	0.00	-7.161 ⁱⁱ	<0.0005

When carrying out the matching interest tasks with the aid of visualisations, all users managed to score a maximum 3 out of 3 for every single task completed. Without the aid of visualisations, the median score across all tasks was also 3, but with an IQR of 1. This difference was significant at the $p < .05$ level, meaning that the use of visualisations helped users get a higher score in completing the tasks. Not only did the use of visualisations help users complete the tasks, they also helped users complete the tasks in a quicker time. The median time taken to complete the tasks without visualisations was 44.0 seconds, compared to a lower median time of 27.50 seconds to complete the tasks with the aid of the visualisations. Once more this difference was significant. The number of mouse clicks used in completing each of the matching interest tasks was also lower with the aid of visualisations. A median of 5 clicks were made by users in completing the tasks without visualisations, compared to a median of 3 clicks with visualisations. This difference was also significant at the $p < .05$ level.

The results show that the visualisations help users complete simple search tasks using the matching interest system across a range of different scenarios. Not only are users able to complete the tasks more accurately with the aid of visualisations, but they are able to do so in a significantly quicker time and without the need for as many mouse clicks. Therefore, the null hypothesis that visualisations do not help in completing the matching interest tasks can be rejected with 95% confidence.

After completing each task, both with and without the aid of visualisations, users were asked to complete a task questionnaire. As part of this questionnaire, users rated the usefulness of each of the three matching interest visualisations (Dartboard, Solar and Text) on a five-point Likert scale. Table 6.3 shows the Friedman two-way analysis of variance (ANOVA) test for the ratings given to the three visualisations.

Table 6.3: Friedman Two-way ANOVA for MInt Visualisations (all Tasks)

	Visualisation			Chi-Square	P
	Dartboard	Solar	Text		
Median	5.0	5.0	3.0	109.500	<0.0005
IQR	1.00	1.00	0.00		
Mean Rank	2.52	2.35	1.13		

The Friedman test shows that there was a significant difference between the users' ratings of the three visualisations across all matching interest tasks. But in order to find out exactly where the difference lay, further analysis was necessary. Therefore, Wilcoxon signed ranks tests were carried out (see Table 6.4).

Table 6.4: Wilcoxon Signed Ranks Tests for MInt Visualisations (all Tasks)

	Wilcoxon Z Statistic	P
Dartboard v Solar	-1.542 ¹	0.123
Dartboard v Text	-7.428 ¹	<0.0005
Solar v Text	-7.321 ¹	<0.0005

There was a significant difference when analysing the Text visualisation against both the Dartboard and Solar visualisations. This was because the users gave higher ratings to both the Dartboard and Solar visualisations than they did to the Text visualisation. Despite not being as highly rated as the other two, the Text visualisation still received positive feedback from the users, gaining a median score

of 3 across all tasks. There was, however, no significant difference between the Dartboard and Solar visualisations, indicating that users were equally happy to use either of the visualisations across all the tasks. The fact that users gave higher scores to the Dartboard and Solar visualisations shows that they generally preferred a visual representation of the results rather than a plain textual depiction.

In addition to rating each visualisation, the task questionnaire asked users to complete five further questions on a five-point Likert scale. They were asked to give a rating to the following statements:

- It was easy to get started on this task
- It was easy to complete this task
- I had sufficient time to complete this task
- I am completely satisfied with my results
- The task was enjoyable

An analysis of these questions is shown in Table 6.5.

Table 6.5: Wilcoxon Signed Ranks Test for Mint Task Questionnaires (all Tasks)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Easy to get started	5.0	1.00	5.0	0.00	-4.182 ¹	<0.0005
Easy to complete	5.0	1.00	5.0	0.00	-4.573 ¹	<0.0005
Sufficient time	5.0	1.00	5.0	0.00	-4.203 ¹	<0.0005
Satisfied with results	4.0	1.00	5.0	0.00	-5.922 ¹	<0.0005
Enjoyable task	5.0	1.00	5.0	0.00	-4.965 ¹	<0.0005

Across all five questions, there was a significant difference between the responses that users gave with the visualisations, compared to the responses without the aid of visualisations. This indicates that users perceived that the visualisations had helped them complete all of the tasks. Not only did users find it easier to get started on questions with the aid of visualisations, but they also found it easier to complete the tasks and do so in a quicker time by using the visualisations. Users were also less

satisfied with their results when completing tasks without the aid of visualisations, and they did not find the tasks as enjoyable as they did when using the visualisations.

6.6.2 Scenario A

This section examines the results from the first type of matching interest task. In this scenario, the search results returned one clear strong match to the user's profile, followed by a cluster of further results that were strong matches to their profile. Figure 6.1 shows the views of the three different visualisations for this task.

Figure 6.1: MInt Visualisations for Scenario A

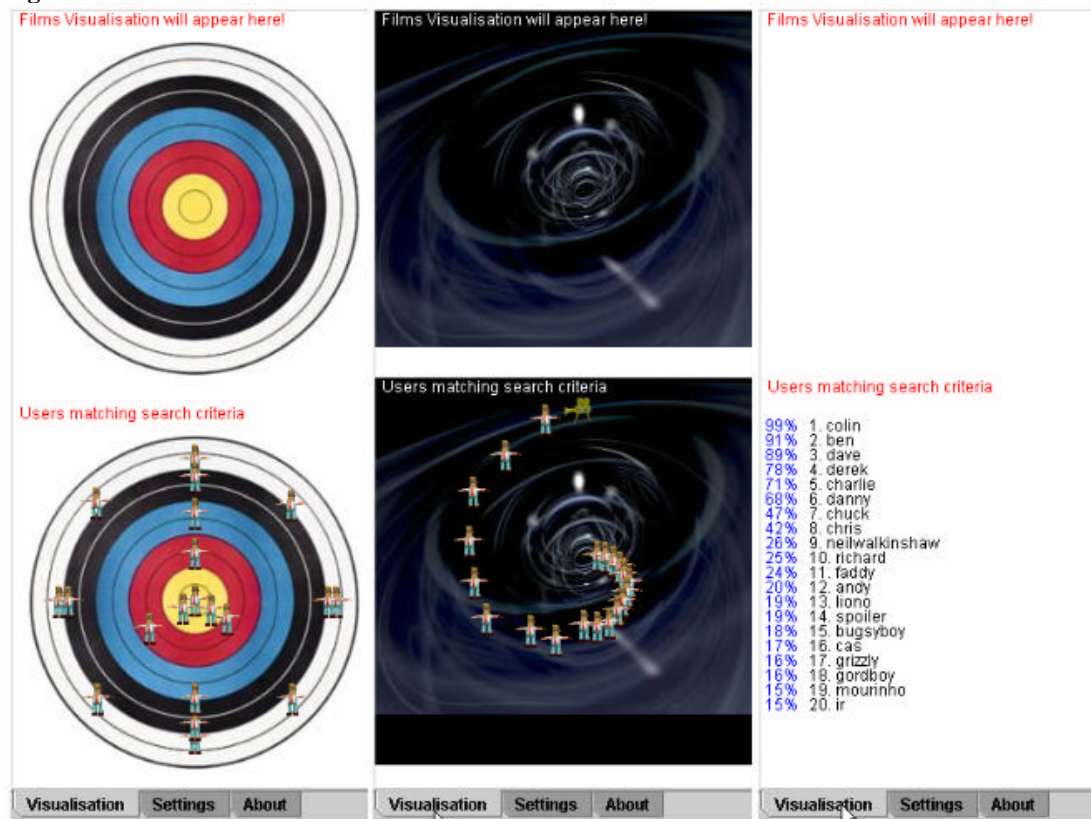


Table 6.6 shows the users' score in completing this task, along with the time taken to complete the task and the number of mouse clicks used.

Table 6.6: Wilcoxon Signed Ranks Test for MInt Data (Scenario A)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Score	3.0	1.00	3.0	0.00	-2.530 ⁱ	0.011
Time	44.0	40.50	28.0	22.25	-2.352 ⁱⁱ	0.019
Clicks	9.0	3.75	3.0	0.00	-3.929 ⁱⁱ	<0.0005

All twenty users scored a maximum 3 out of 3 when completing the task with the aid of visualisations. Without using visualisations, users had a median score of 3, but with an IQR of 1. This difference was significant at the $p < .05$ level, meaning that the use of visualisations helped users get a higher score when there was one clear strong match followed by a cluster of strong matches to their profile. The median time taken to complete the task without visualisations was 44 seconds, compared to a lower median time of 28 seconds to complete this particular task with the aid of the visualisations. This difference was also significant. The number of mouse clicks used to complete the first matching interest task was also lower with the aid of visualisations. A median of 9 clicks were made by users in completing the tasks without visualisations, compared to a median of 3 clicks with visualisations. This difference was also significant at the $p < .05$ level.

The results showed that for this type of task, the visualisations helped users complete the task more accurately and in a more efficient manner. Therefore, the null hypothesis that visualisations do not help in completing this type of task can be rejected with 95% confidence.

Table 6.7 shows the Friedman two-way ANOVA test for the ratings given to the three visualisations for this task.

Table 6.7: Friedman Two-way ANOVA for MInt Visualisations (Scenario A)

	Visualisation			Chi-Square	P
	Dartboard	Solar	Text		
Median	4.5	5.0	3.0	28.676	<0.0005
IQR	1.00	0.00	1.00		
Mean Rank	2.25	2.63	1.13		

The Friedman test showed that there was a significant difference between the users' ratings of the three visualisations for this task. Wilcoxon signed ranks tests (see Table 6.8) were conducted in order to investigate the source of the differences.

Table 6.8: Wilcoxon Signed Ranks Tests for MInt Visualisations (Scenario A)

	Wilcoxon Z Statistic	P
Dartboard v Solar	-2.000 ¹¹	0.046
Dartboard v Text	-3.787 ¹	<0.0005
Solar v Text	-3.874 ¹	<0.0005

There was a significant difference when analysing the Text visualisation against both the Dartboard and Solar visualisations. This was because the users preferred a visual representation of results with higher ratings being given to both the Dartboard and Solar visualisations than were given to the Text visualisation. When comparing the Dartboard and Solar visualisations, there was also a significant difference, with the Solar visualisation being preferred by users.

For this particular task, there was a significant difference between all three visualisations, with the Solar visualisation being rated the highest, followed by the Dartboard visualisation, and then the Text visualisation. The results show that, in cases where there are a series of strong items of interest, the users preferred to use the Solar visualisation. Feedback from users indicated that this was due to the fact that the strong results were clearer on the Solar visualisation, whereas the cluster of icons in the centre of the Dartboard made it harder to distinguish individual matches.

Table 6.9 shows the users' responses to the Likert scale questions for the first scenario.

Table 6.9: Wilcoxon Signed Ranks Test for MInt Task Questionnaires (Scenario A)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Easy to get started	5.0	1.00	5.0	0.00	-1.814 ¹	0.070
Easy to complete	4.5	1.00	5.0	0.00	-2.648 ¹	0.008
Sufficient time	5.0	1.00	5.0	0.00	-2.271 ¹	0.023
Satisfied with results	4.0	2.00	5.0	0.00	-3.244 ¹	0.001
Enjoyable task	5.0	2.00	5.0	0.00	-2.565 ¹	0.010

There was only one question where there was no significant difference between the users' responses with visualisations, compared to the responses without the aid of visualisations. Users found it just as easy to get started with the task without the visualisations as they did using the visualisations. Despite this, users found it easier to complete the tasks using visualisations and felt they had more time with the aid of visualisations. Users were also happier with their results using visualisations and found the tasks more enjoyable with the visualisations.

6.6.3 Scenario B

This section examines the results from the second type of matching interest task. In this scenario, the search results included three clear strong matches to the user's profile. MInt visualisations for this task are shown in Figure 6.2.

Figure 6.2: MInt Visualisations for Scenario B

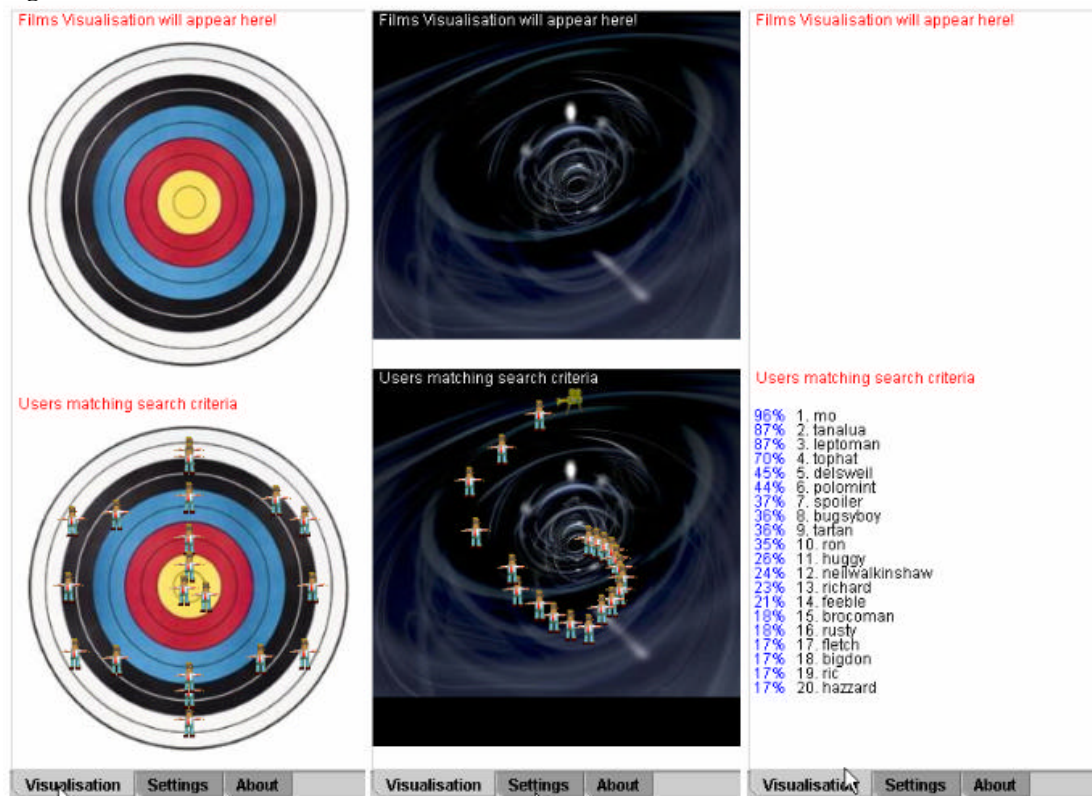


Table 6.10 shows the users' score in completing this task, along with the time taken to complete the task and the number of mouse clicks used.

Table 6.10: Wilcoxon Signed Ranks Test for MInt Data (Scenario B)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Score	2.0	1.00	3.0	0.00	-3.127 ⁱ	0.002
Time	44.5	48.75	26.0	18.00	-3.771 ⁱⁱ	<0.0005
Clicks	5.0	1.00	3.0	0.00	-3.915 ⁱⁱ	<0.0005

As with the first task, all twenty users scored a maximum 3 out of 3 when completing the second type of task with the aid of visualisations. Without visualisations, users had a median score of 2, with an IQR of 1. This difference was significant at the $p < .05$ level, meaning that the use of visualisations helped users get a higher score when there were three clear strong matches to their profile. The median time taken to complete the task with visualisations was 26 seconds, compared to a higher median time of 44.50 seconds to complete the tasks without the aid of visualisations. Again, this difference was significant. The difference between the number of mouse clicks used to complete the task was also significant. A median of 3 clicks were used to complete the task using visualisations, compared to 5 clicks without the aid of visualisations.

For this type of task, the visualisations helped users complete the task more accurately and in a more efficient manner. Therefore the null hypothesis that visualisations do not help in completing this type of task can be rejected with 95% confidence.

Table 6.11 shows the Friedman two-way ANOVA test for the ratings given to the three visualisations for this scenario.

Table 6.11: Friedman Two-way ANOVA for MInt Visualisations (Scenario B)

	Visualisation			Chi-Square	P
	Dartboard	Solar	Text		
Median	4.5	5.0	3.0	36.353	<0.0005
IQR	1.00	0.00	0.00		
Mean Rank	2.35	2.65	1.00		

Again, the Friedman test showed that there was a significant difference between the users' ratings of the three visualisations for this task. In order to find out exactly where the difference lay, Wilcoxon signed ranks tests were carried out (see Table 6.12).

Table 6.12: Wilcoxon Signed Ranks Tests for MInt Visualisations (Scenario B)

	Wilcoxon Z Statistic	P
Dartboard v Solar	-2.121 ¹¹	0.034
Dartboard v Text	-4.042 ¹	<0.0005
Solar v Text	-4.064 ¹	<0.0005

Users gave higher ratings to both the Solar and Dartboard visualisations than they did to the Text visualisation, resulting in a statistically significant difference when comparing either the Solar or Dartboard visualisations against the Text visualisation. There was also a significant difference between the Dartboard and Solar visualisations for this particular task with the Solar visualisation being rated higher than the Dartboard visualisation. This meant that for this task, there was a significant difference between all three visualisations, with the Solar visualisation being rated the highest, followed by the Dartboard visualisation and then the Text visualisation. As was the case with the first task, the users indicated that their preference for the Solar visualisation was due to the fact that it drew the strong results in a clearer manner, whereas the cluster of icons in the centre of the Dartboard made it harder to distinguish individual matches.

Table 6.13 shows the users' responses to the Likert scale questions for the second scenario.

Table 6.13: Wilcoxon Signed Ranks Test for MInt Task Questionnaires (Scenario B)

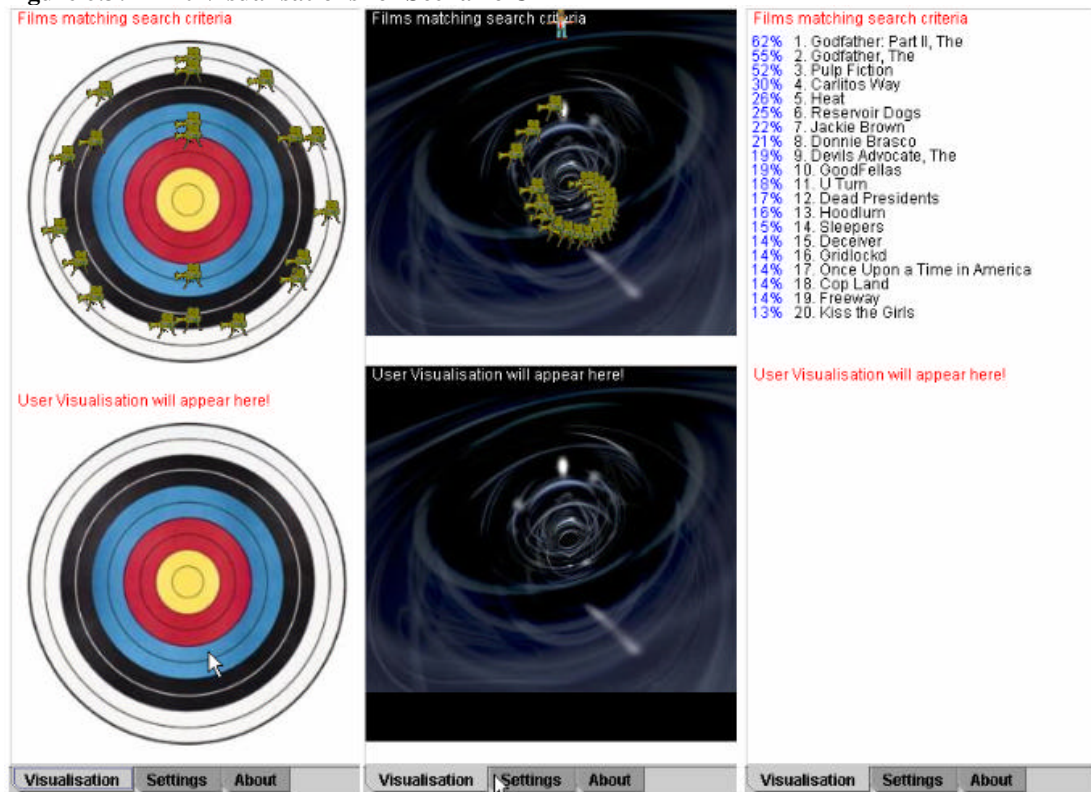
	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Easy to get started	5.0	1.00	5.0	0.00	-2.646 ¹	0.008
Easy to complete	5.0	1.00	5.0	0.00	-2.887 ¹	0.004
Sufficient time	5.0	1.00	5.0	0.00	-2.333 ¹	0.020
Satisfied with results	4.0	1.00	5.0	0.00	-3.127 ¹	0.002
Enjoyable task	5.0	1.00	5.0	0.00	-2.333 ¹	0.020

Across all five questions, there was a significant difference between the responses that users gave with the visualisations, compared to the responses without the aid of visualisations. This shows that users thought that the visualisations helped them complete the task. Not only did users find it easier to get started on questions with the aid of visualisations, but they also found it easier to complete the task and do so in a quicker time by using the visualisations. Users were also less satisfied with their results when completing tasks without the aid of visualisations, and they did not find the tasks as enjoyable without visualisations.

6.6.4 Scenario C

This section examines the results for the third type of matching interest task. In this scenario, the best matches to the users' profile were weaker than in the second scenario. Once again, there were three clear matches within the search results. MInt visualisations for this task are shown in Figure 6.3.

Figure 6.3: MInt Visualisations for Scenario C



The users' score in completing this type of task, along with the time taken to complete the task and the number of mouse clicks used are shown in Table 6.14.

Table 6.14: Wilcoxon Signed Ranks Test for MInt Data (Scenario C)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Score	2.0	1.00	3.0	0.00	-3.500 ⁱ	<0.0005
Time	54.5	157.00	30.5	27.25	-3.501 ⁱⁱ	<0.0005
Clicks	4.5	3.25	3.0	0.00	-3.439 ⁱⁱ	0.001

Again, all twenty users scored a maximum 3 out of 3 when completing this type of task with the aid of visualisations. Without visualisations, users had a median score of 2, with an IQR of 1. This difference was significant at the $p < .05$ level, meaning that the use of visualisations helped users get a higher score when there were three clear weaker matches to their profile. The median time taken to complete the task with visualisations was 30.50 seconds, compared to a higher median time of 54.50 seconds to complete the tasks without the aid of visualisations. Again, this difference was significant. The number of mouse clicks used to complete this task was also lower when using the visualisations, resulting in a significant difference. A median of 3 clicks were used to complete the task using visualisations, compared to 4.5 clicks without the aid of visualisations.

For this type of task, the visualisations helped users complete the task more accurately and in a more efficient manner. Therefore, the null hypothesis that visualisations do not help in completing this type of task can be rejected with 95% confidence.

Table 6.15 shows the Friedman two-way ANOVA test for the ratings given to the three visualisations for this scenario.

Table 6.15: Friedman Two-way ANOVA for MInt Visualisations (Scenario C)

	Visualisation			Chi-Square	P
	Dartboard	Solar	Text		
Median	5.0	4.0	3.0	26.537	<0.0005
IQR	0.00	1.00	0.00		
Mean Rank	2.68	2.13	1.20		

Given that the Friedman test showed that there was a significant difference between the users' ratings of the three visualisations for this task, Wilcoxon signed ranks tests were carried out to investigate the source of the difference (see Table 6.16).

Table 6.16: Wilcoxon Signed Ranks Tests for MInt Visualisations (Scenario C)

	Wilcoxon Z Statistic	P
Dartboard v Solar	-2.066 ¹	0.039
Dartboard v Text	-3.906 ¹	<0.0005
Solar v Text	-3.358 ¹	0.001

The Text visualisation did not score as highly as either the Dartboard or Solar visualisations, resulting in a statistically significant difference between the ratings of the Text visualisation and the other two visualisations for this type of task. There was also a significant difference between the Dartboard and Solar visualisations, with users finding the Dartboard visualisation more useful in completing the task than the Solar visualisation. Therefore, for this task, there was a significant difference between all three visualisations, with the Dartboard visualisation being favoured most, followed by the Solar visualisation and then the Text visualisation. In contrast to the first two scenarios, users indicated that Dartboard visualisation made the results clearer than the Solar visualisation for this particular task.

Table 6.17 shows the users' responses to the Likert scale questions for the third scenario.

Table 6.17: Wilcoxon Signed Ranks Test for MInt Task Questionnaires (Scenario C)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Easy to get started	5.0	0.75	5.0	0.00	-2.070 ¹	0.038
Easy to complete	5.0	0.00	5.0	0.00	-1.857 ¹	0.063
Sufficient time	5.0	1.00	5.0	0.00	-2.232 ¹	0.026
Satisfied with results	4.0	1.75	5.0	0.00	-2.994 ¹	0.003
Enjoyable task	5.0	1.00	5.0	0.00	-2.640 ¹	0.008

Users found it significantly easier to get started on this task when using the visualisations. However, there was no significant difference between users' responses on whether they found the task easy to complete. This indicates that users found the task easy to complete without the aid of the visualisations. Despite this, users did not score as highly when completing the task without the visualisations (as shown in Table 6.14). Users clearly recognised this fact, as they were significantly more satisfied with their results when they used the visualisations. Users responded that they felt they had less time without the aid of visualisations and they enjoyed the task more when using the visualisations.

6.6.5 Scenario D

For the final type of matching interest task, each user's search returned only a handful of weaker results in total. Figure 6.4 shows the views of the three different visualisations for this task.

Figure 6.4: MInt Visualisations for Scenario D

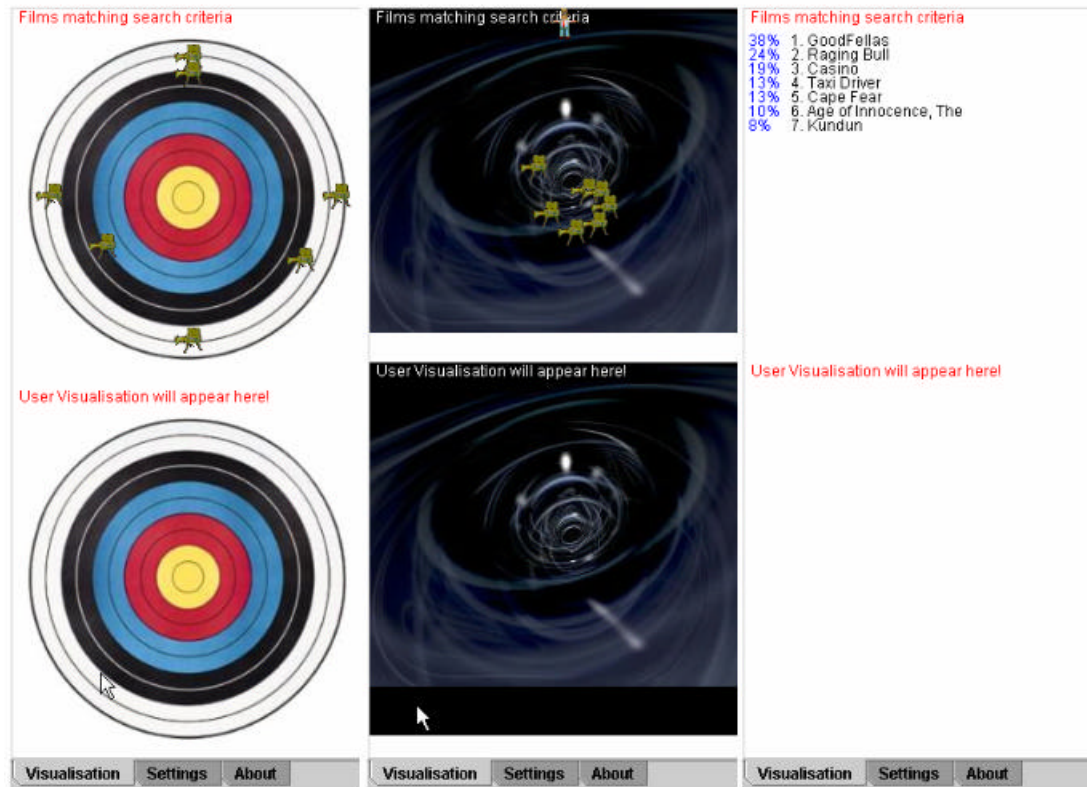


Table 6.18 shows the users' score in completing this task, along with the time taken to complete the task and the number of mouse clicks used.

Table 6.18: Wilcoxon Signed Ranks Test for MInt Data (Scenario D)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Score	3.0	1.00	3.0	0.00	-2.449 ⁱ	0.014
Time	38.5	11.75	27.0	19.50	-2.819 ⁱⁱ	0.005
Clicks	4.0	1.75	3.0	0.00	-3.130 ⁱⁱ	0.002

As was the case with the previous three scenarios, all twenty users scored a maximum 3 out of 3 when completing this type of task with the aid of visualisations. Without visualisations, users had a median score of 3, with an IQR of 1. This difference was significant at the $p < .05$ level, meaning that the use of visualisations helped users get a higher score even when there were only a handful of search results. The median time taken to complete the task with visualisations was 27 seconds, compared to a higher median time of 38.50 seconds without the aid of visualisations. Again, this difference was significant. The difference between the

number of mouse clicks used to complete the task was also significant. A median of 3 clicks were used to complete the task using visualisations, compared to 4 clicks without the aid of visualisations.

For this type of task, the visualisations helped users complete the task more accurately and in a more efficient manner. Therefore, the null hypothesis that visualisations do not help in completing this type of task can be rejected with 95% confidence.

Table 6.19 shows the Friedman two-way ANOVA test for the ratings given to the three visualisations for this scenario.

Table 6.19: Friedman Two-way ANOVA for MInt Visualisations (Scenario D)

	Visualisation			Chi-Square	P
	Dartboard	Solar	Text		
Median	5.0	5.0	3.0	23.662	<0.0005
IQR	1.00	1.00	0.00		
Mean Rank	2.43	2.38	1.20		

Since the Friedman test returned a significant difference between the users' ratings of the three visualisations for this task, Wilcoxon signed ranks tests were carried out to investigate the source of the difference (see Table 6.20).

Table 6.20: Wilcoxon Signed Ranks Tests for MInt Visualisations (Scenario D)

	Wilcoxon Z Statistic	P
Dartboard v Solar	-0.184 ¹	0.854
Dartboard v Text	-3.266 ¹	0.001
Solar v Text	-3.601 ¹	<0.0005

There was a significant difference when comparing the Text visualisation against both the Dartboard and Solar visualisations. As was the case with the first three tasks, users preferred a visual representation of the results rather than a textual depiction, and they gave higher ratings to both the Dartboard and Solar visualisations than they did to the Text visualisation. There was, however, no significant difference between the Dartboard and Solar visualisations, indicating that users were equally happy to use either of these visualisations for this specific type of task.

Table 6.21 shows the users' responses to the Likert scale questions for the final matching interest scenario.

Table 6.21: Wilcoxon Signed Ranks Test for MInt Task Questionnaires (Scenario D)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Easy to get started	5.0	1.00	5.0	0.00	-2.333 ¹	0.020
Easy to complete	5.0	1.00	5.0	0.00	-1.667 ¹	0.096
Sufficient time	5.0	0.00	5.0	0.00	-1.732 ¹	0.083
Satisfied with results	5.0	1.00	5.0	0.00	-2.640 ¹	0.008
Enjoyable task	4.5	1.00	5.0	0.00	-2.496 ¹	0.013

Users found it significantly easier to get started on this task when using the visualisations. However, users responded that they found the task easy to complete both with and without the visualisations. They also found that they had sufficient time to complete the task whether they used the visualisations or not. Despite this, users were still significantly more satisfied with their results, and found the task more enjoyable when they used the visualisations.

6.6.6 Post-System Questionnaire

After completing all the matching interest tasks, both with and without the aid of visualisations, users were asked to complete a post-system questionnaire (see Appendix D). Users were firstly asked to indicate their view of the matching interest visualisations by completing a set of semantic differentials. They were asked to evaluate the visualisations based upon how 'simple'/'complex', 'reliable'/'unreliable', 'interesting'/'boring', 'attractive'/'unattractive', 'informative'/'uninformative' and 'relevant'/'irrelevant' they found them. Table 6.22 shows the subjects' attitude towards the pairs of descriptors on a five-point scale. The table presents the median, IQR, minimum and maximum scores for each of the semantic differential pairs and for the overall differential score.

Table 6.22: Post-test View of the MInt Visualisations

Differential	Median	IQR	Min	Max
Simple	5.0	0.75	4	5
Reliable	5.0	0.75	4	5
Interesting	5.0	0.75	3	5
Attractive	5.0	1.00	4	5
Informative	5.0	1.00	3	5
Relevant	5.0	0.00	4	5
<i>Overall</i>	<i>28.0</i>	<i>3.00</i>	<i>24</i>	<i>30</i>

Overall, users were extremely positive about the matching interest visualisations with a median score of 28 across all the differential pairs. Furthermore, each of the individual pairs of descriptors had a median score of 5, indicating the users' positive perception of the visualisations. Given that in the pre-test questionnaire, some users had indicated that their previous experience with online communities had been somewhat stressful and frustrating, this feedback on the visualisations is encouraging.

Users believed that the visualisations provided information that was interesting, informative and relevant to the tasks they were carrying out, and did so in a reliable manner. The visualisations were also found to be aesthetically pleasing and attractive to users, presenting information in a simple manner.

Users were then asked to complete a series of five-point Likert scale questions on the usability of the various matching interest visualisations. They were asked to give a rating to the following statements:

- It was easy to learn to use the visualisations
- It was easy to use the visualisations
- I completely understand how to use the visualisations
- It was easy to assess the usefulness of something from the visualisations
- I intuitively understood what the visualisations were depicting
- No further explanation of the individual visualisations is needed before I would feel comfortable using them

An analysis of these questions is shown in Table 6.23.

Table 6.23: Post-test MInt Usability Questions

Likert scale question	Median	IQR	Min	Max
Easy to learn to use	5.0	0.00	4	5
Easy to use	5.0	1.00	4	5
Understand how to use	5.0	0.00	4	5
Easy to assess usefulness	5.0	0.75	4	5
Intuitively understand visualisations	5.0	1.00	4	5
No further explanation necessary	5.0	0.75	4	5

For each of the six Likert scale questions, the median response given by users was 5. In addition to being easy to use, users found that it was easy to learn how to use the visualisations and they fully understood how to use the matching interest visualisations. Users responded that it was easy to assess the usefulness of something by looking at the visualisations and that they intuitively understood the data being depicted, with no further explanation of the individual visualisations being necessary.

Users were then asked to rate the three different matching interest visualisations across all the tasks they carried out. Table 6.24 shows the Friedman two-way ANOVA test for the ratings given to the three visualisations.

Table 6.24: Post-test Friedman Two-way ANOVA for MInt Visualisations

	Visualisation			Chi-Square	P
	Dartboard	Solar	Text		
Median	5.0	4.0	3.0	19.176	<0.0005
IQR	1.00	2.00	1.00		
Mean Rank	2.55	2.15	1.30		

The Friedman test shows that there was a significant difference between the users' ratings of the three visualisations across all matching interest tasks. In order to identify the source of the difference, Wilcoxon signed ranks tests were conducted (see Table 6.25).

Table 6.25: Post-test Wilcoxon Signed Ranks Tests for MInt Visualisations

	Wilcoxon Z Statistic	P
Dartboard v Solar	-1.687 ¹	0.092
Dartboard v Text	-3.555 ¹	<0.0005
Solar v Text	-3.129 ¹	0.002

There was a significant difference when analysing the Text visualisation against both the Dartboard and Solar visualisations. This was because the users gave higher ratings to both the Dartboard and Solar visualisations than they did to the Text visualisation. Despite not being as highly rated as the other two, the Text visualisation still received positive feedback from the users, gaining a median score of 3 across all tasks.

There was, however, no significant difference between the Dartboard and Solar visualisations, indicating that users were equally happy to use either of the visualisations across all the tasks.

Users then filled out a further series of semantic differentials concerning the information that was presented by the visualisations. They were asked to evaluate whether the information provided by the visualisations was ‘timely’/‘untimely’, ‘simple’/‘complex’, ‘structured’/‘incoherent’, ‘clear’/‘confusing’, ‘informative’/‘uninformative’, and ‘unobtrusive’/‘obtrusive’. Table 6.26 shows the subjects’ attitude towards the pairs of descriptors on a five-point scale, presenting the median, IQR, minimum and maximum scores for each of the semantic differential pairs and for the overall differential score.

Table 6.26: Post-test View of the Information Provided by MInt Visualisations

Differential	Median	IQR	Min	Max
Timely	5.0	0.75	4	5
Simple	4.5	1.00	4	5
Structured	5.0	1.00	3	5
Clear	5.0	1.00	4	5
Informative	5.0	1.00	4	5
Unobtrusive	5.0	0.00	4	5
<i>Overall</i>	<i>29.0</i>	<i>3.00</i>	<i>24</i>	<i>30</i>

Overall, users were extremely positive about the way that the matching interest visualisations presented information to them. The only semantic differential pair that did not have a median score of 5 was ‘simple’/’complex’, which still had a median score of 4.50. Users found that the visualisations presented information in a timely manner that was simple and structured. The information was also found to be clear and informative, accessible in an unobtrusive fashion to the users.

Users also completed a series of Likert-scale questions on the usefulness of the matching interest visualisations. They had to give a rating to the following statements:

- I would trust the visualisations to find items of interest
- The visualisations made it easier to complete the tasks
- I would use the visualisations again

An analysis of these questions is shown in Table 6.27.

Table 6.27: Post-test View of Usefulness of MInt Visualisations

Likert scale question	Median	IQR	Min	Max
Trust the visualisations	5.0	1.00	4	5
Easier to complete tasks	5.0	1.00	3	5
Would use visualisations again	5.0	0.75	3	5

For each of the three Likert scale questions, the median response from users was 5. Users trusted the visualisations and found that it was easier to complete the tasks with the aid of the visualisations. They also responded that they would use the visualisations again in the future.

6.7 Bulletin Board

The bulletin board tasks examine whether the presentation of visualisations aids users in browsing and finding information within bulletin boards.

6.7.1 Performance across All Scenarios

Before examining the bulletin board system for each of the individual tasks and scenarios that formed part of the experiments, the data across all tasks as a whole will be discussed. As was the case with the matching interest system, all statistical tests on the bulletin board system were carried out at the $p < .05$ level of significance. Table 6.28 shows the users' score in completing all tasks, along with the time taken to complete them and the number of mouse clicks used.

Table 6.28: Wilcoxon Signed Ranks Test for BulB Data (all Tasks)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Score	2.5	1.00	3.0	0.00	-5.891 ⁱ	<0.0005
Time	89.5	74.25	37.5	74.00	-6.638 ⁱⁱ	<0.0005
Clicks	9.0	7.00	4.0	4.00	-6.663 ⁱⁱ	<0.0005

When carrying out the bulletin board tasks with the aid of visualisations, all users scored a maximum 3 out of 3 for each of the four different tasks. Without the aid of visualisations, the median score across all tasks was 2.5, with an IQR of 1.00. This difference was significant at the $p < .05$ level, meaning that the use of visualisations helped users achieve a higher score when completing the tasks. Not only did the use of visualisations help users complete the tasks, they also helped users complete the tasks in a quicker time. The median time taken to complete the tasks without visualisations was 89.50 seconds, compared to a lower median time of 37.50 seconds to complete the tasks with the aid of the visualisations. Once more this difference was significant. The number of mouse clicks used in completing each of the matching interest tasks was also lower with the aid of visualisations. A median of 9 clicks were made by users in completing the tasks without visualisations, compared to a median of 4 clicks with visualisations. This difference was also significant at the $p < .05$ level.

The results show that the visualisations help users in browsing and finding information within bulletin boards across a range of different scenarios. Not only are users able to complete the tasks more accurately with the aid of visualisations, but

they are able to do so in a significantly quicker time and without the need for as many mouse clicks. Therefore, the null hypothesis that visualisations do not help in completing the bulletin board tasks can be rejected with 95% confidence.

As was the case with the matching interest system, users were asked to rate the usefulness of the three bulletin board visualisation (Flower, Pie and Timeline) for each of the different tasks. Table 6.29 shows the Friedman two-way ANOVA test for the ratings given to the three visualisations for this task.

Table 6.29: Friedman Two-way ANOVA for BulB Visualisations (all Tasks)

	Visualisation			Chi-Square	P
	Flower	Pie	Timeline		
Median	4.0	4.0	5.0	9.840	0.007
IQR	1.00	2.75	1.00		
Mean Rank	1.91	1.84	2.24		

The Friedman test showed that there was a significant difference between the users' ratings of the three visualisations across all bulletin board tasks. Wilcoxon signed ranks tests (see Table 6.30) were conducted in order to investigate the source of the differences.

Table 6.30: Wilcoxon Signed Ranks Tests for BulB Visualisations (all Tasks)

	Wilcoxon Z Statistic	P
Flower v Pie	-2.336 ⁱ	0.019
Flower v Timeline	-2.994 ⁱⁱ	0.003
Pie v Timeline	-3.477 ⁱⁱ	0.001

There was a significant difference when the Timeline visualisation was compared to both the Flower and Pie visualisations, with the Timeline visualisation being rated significantly higher by users when considering all tasks as a whole. There was also a significant difference between the Flower and Pie visualisations across all tasks with Flower visualisation being rated higher by users. Therefore, across all tasks as a whole, there was a significant difference between all visualisations, with the Timeline visualisation rated the highest, followed by the Flower visualisation and then the Pie visualisation.

As was the case with the matching interest system, users were asked to answer a series of Likert scale questions after completing each of the tasks. Table 6.31 shows the users' responses to these Likert scale questions across all of the different scenarios.

Table 6.31: Wilcoxon Signed Ranks Test for BulB Task Questionnaires (all Tasks)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Easy to get started	5.0	1.00	5.0	0.00	-4.986 ¹	<0.0005
Easy to complete	4.0	1.00	5.0	0.00	-5.860 ¹	<0.0005
Sufficient time	5.0	1.00	5.0	0.00	-4.715 ¹	<0.0005
Satisfied with results	4.0	1.00	5.0	0.00	-5.835 ¹	<0.0005
Enjoyable task	5.0	1.00	5.0	0.00	-4.956 ¹	<0.0005

Across all five questions, there was a significant difference between the responses that users gave with the visualisations, compared to the responses without the aid of visualisations. This is indicative of users perceiving that the visualisations helped them complete all of the bulletin board tasks. Not only did users find it easier to get started on questions with the aid of visualisations, but they also found it easier to complete the tasks and do so in a quicker time by using the visualisations. Users were also more satisfied with their results when completing tasks with the aid of visualisations, and they found the tasks more enjoyable when using the visualisations.

6.7.2 Scenario A

This section examines the results from the first type of bulletin board task. In this scenario, users were asked to browse the bulletin board and identify the three most dominant posters. Figure 6.5 shows the views of the three different visualisations for this task.

Figure 6.5: BulB Visualisations for Scenario A

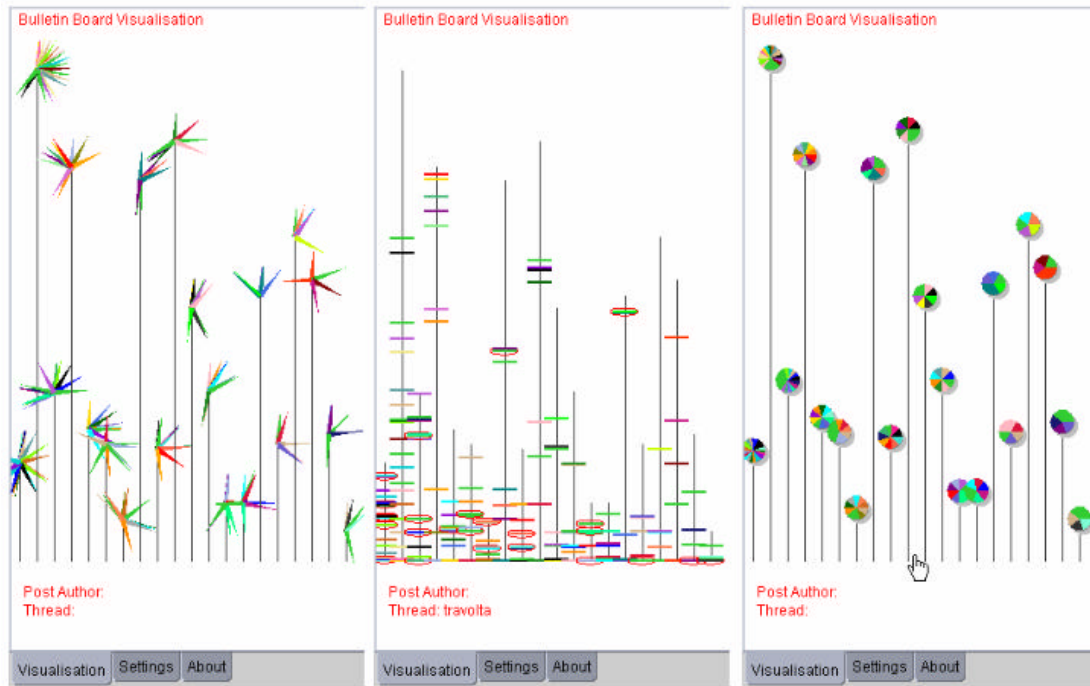


Table 6.32 shows the users' score in completing this task, along with the time taken to complete the task and the number of mouse clicks used.

Table 6.32: Wilcoxon Signed Ranks Test for BulB Data (Scenario A)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Score	3.0	1.00	3.0	0.00	-2.646 ⁱ	0.008
Time	142.0	76.50	119.5	61.25	-2.521 ⁱⁱ	0.012
Clicks	16.0	6.75	9.0	5.00	-3.197 ⁱⁱ	0.001

All twenty users scored a maximum 3 out of 3 when completing the task with the aid of visualisations. Without using visualisations, users had a median score of 3, but with an IQR of 1. This difference was significant at the $p < .05$ level, meaning that the use of visualisations helped users get a higher score when attempting to identify dominant posters in the bulletin board. The median time taken to complete the task without visualisations was 142 seconds, compared to a lower median time of 119.50 seconds to complete this particular task with the aid of the visualisations. This difference was also significant. The number of mouse clicks used to complete the first matching interest task was also lower with the aid of visualisations. A median of 16 clicks were made by users in completing the tasks without visualisations,

compared to a median of 9 clicks with visualisations. This difference was also significant at the $p < .05$ level.

The results showed that for this type of task, the visualisations helped users complete the task more accurately and in a more efficient manner. Therefore, the null hypothesis that visualisations do not help in completing this type of bulletin board task can be rejected with 95% confidence.

Table 6.33 shows the Friedman two-way ANOVA test for the ratings given to the three visualisations for this task.

Table 6.33: Friedman Two-way ANOVA for BulB Visualisations (Scenario A)

	Visualisation			Chi-Square	P
	Flower	Pie	Timeline		
Median	4.0	5.0	4.0	26.600	<0.0005
IQR	1.00	0.00	0.75		
Mean Rank	1.38	2.85	1.78		

Since the Friedman test returned a significant difference between the users' ratings of the three visualisations for this task, Wilcoxon signed ranks tests were carried out to investigate the source of the difference (see Table 6.34).

Table 6.34: Wilcoxon Signed Ranks Tests for BulB Visualisations (Scenario A)

	Wilcoxon Z Statistic	P
Flower v Pie	-3.963 ⁱⁱ	<0.0005
Flower v Timeline	-1.604 ⁱⁱ	0.109
Pie v Timeline	-3.466 ⁱ	0.001

There was a significant difference when comparing the Pie visualisation against both the Flower and Timeline visualisations for this first scenario. This was because the users gave higher ratings to the Pie visualisation than they did to either the Flower or Timeline visualisations. There was, however, no significant difference between the ratings given to the Flower and Timeline visualisations. This indicates that users preferred to use the Pie visualisation to spot dominant users in the bulletin board, with neither the Flower or Timeline visualisation being as useful. The fact that all the posts from individual users are grouped together in a Pie means that it is easier

to pick out the spread of individual contributors in and across threads, thus making the identification of dominant users more straightforward. Despite not being as highly favoured as the Pie visualisation, both the Flower and Timeline visualisations still received positive feedback from users, and both had a median score of 4 for the first task.

Table 6.35 shows the users' responses to the Likert scale questions for the first bulletin board scenario.

Table 6.35: Wilcoxon Signed Ranks Test for BulB Task Questionnaires (Scenario A)

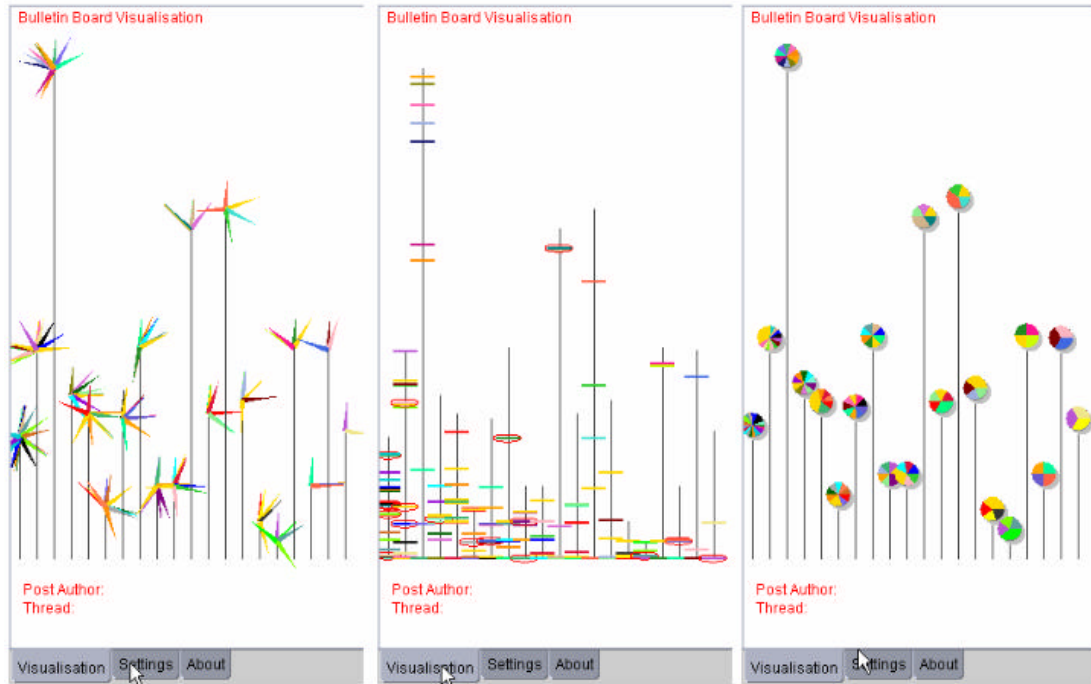
	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Easy to get started	4.0	1.00	5.0	0.00	-2.812 ¹	0.005
Easy to complete	4.0	0.00	5.0	0.00	-3.704 ¹	<0.0005
Sufficient time	4.0	2.00	5.0	0.00	-3.360 ¹	0.001
Satisfied with results	4.0	1.00	5.0	0.00	-3.602 ¹	<0.0005
Enjoyable task	4.0	2.00	5.0	0.00	-3.256 ¹	0.001

Across all five questions, there was a significant difference between the responses that users gave with the visualisations, compared to the responses without the aid of visualisations. This indicates that users preferred to use the visualisations to complete the task. In addition to finding it easier to get started on questions with the aid of visualisations, users also found it easier to complete the tasks and do so in a quicker time with the aid of the visualisations. Users were less satisfied with their results when completing tasks without the aid of visualisations, and they did not find the tasks as enjoyable without visualisations.

6.7.3 Scenario B

For the second type of bulletin board task, users were required to examine popular threads which had posts in the last week, and identify the three threads with the most posts. BulB visualisations for this task are shown in Figure 6.6.

Figure 6.6: BulB Visualisations for Scenario B



The users' score in completing this type of task, along with the time taken to complete the task and the number of mouse clicks used are shown in Table 6.36.

Table 6.36: Wilcoxon Signed Ranks Test for BulB Data (Scenario B)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Score	3.0	1.00	3.0	0.00	2.333 ⁱ	0.020
Time	69.5	37.50	19.5	39.00	-3.361 ⁱⁱ	0.001
Clicks	8.0	2.75	3.0	0.75	-3.636 ⁱⁱ	<0.0005

As with the first scenario, all users scored a maximum 3 out of 3 when completing the second type of task with the aid of visualisations. Without visualisations, users had a median score of 3, with an IQR of 1. This difference was significant at the $p < .05$ level, meaning that the use of visualisations helped users get a higher score when they were trying to identify threads with the most posts. The median time taken to complete the task with visualisations was 19.50 seconds, compared to a higher median time of 69.50 seconds to complete the tasks without the aid of visualisations. Again, this difference was significant. The difference between the number of mouse clicks used to complete the task was also significant. A median of 3 clicks were used

to complete the task using visualisations, compared to 8 clicks without the aid of visualisations.

For this type of task, the visualisations helped users complete the task more accurately and in a more efficient manner. Therefore, the null hypothesis that visualisations do not help in completing this type of task can be rejected with 95% confidence.

Table 6.37 shows the Friedman two-way ANOVA test for the ratings given to the three visualisations for this scenario.

Table 6.37: Friedman Two-way ANOVA for BulB Visualisations (Scenario B)

	Visualisation			Chi-Square	P
	Flower	Pie	Timeline		
Median	5.0	4.0	5.0	11.231	0.004
IQR	0.00	1.00	1.00		
Mean Rank	2.40	1.55	2.05		

Given that the Friedman test showed that there was a significant difference between the users' ratings of the three visualisations for this task, Wilcoxon signed ranks tests were carried out to investigate the source of the difference (see Table 6.38).

Table 6.38: Wilcoxon Signed Ranks Tests for BulB Visualisations (Scenario B)

	Wilcoxon Z Statistic	P
Flower v Pie	-2.968 ⁱ	0.003
Flower v Timeline	-1.667 ⁱ	0.096
Pie v Timeline	-2.000 ⁱⁱ	0.046

There was a significant difference when comparing the Pie visualisation against both the Flower and Timeline visualisations. This was because the users gave higher ratings to both the Flower and Timeline visualisations than they did to the Pie visualisation. There was, however, no significant difference between the Flower and Timeline visualisations, indicating that users were equally happy to use either of these visualisations for this specific type of task. Although the Pie visualisation was rated least useful for this particular scenario, it did receive a median score of 4, indicated that it was still useful in completing the task.

Table 6.39 shows the users' responses to the Likert scale questions for the second bulletin board scenario.

Table 6.39: Wilcoxon Signed Ranks Test for BulB Task Questionnaires (Scenario B)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Easy to get started	5.0	0.75	5.0	0.00	-1.667 ¹	0.096
Easy to complete	4.0	1.00	5.0	0.00	-2.814 ¹	0.005
Sufficient time	5.0	0.00	5.0	0.00	-1.414 ¹	0.157
Satisfied with results	4.5	1.00	5.0	0.00	-2.887 ¹	0.004
Enjoyable task	5.0	1.00	5.0	0.00	-2.449 ¹	0.014

For this task, users found it just as easy to get started without the visualisations as they did with the visualisations. However, users did find it easier to complete the task with the visualisations. Despite the visualisations helping them to complete the task, the users still felt that they had enough time to complete the task without visualisations. Nonetheless, users were significantly more satisfied with their results with the aid of visualisations and found the task more enjoyable when using the visualisations.

6.7.4 Scenario C

The third type of bulletin board task required users to examine popular threads with many posts and identify three threads which were becoming stagnant with little or no recent activity. BulB visualisations for this task are shown in Figure 6.7.

Figure 6.7: BulB Visualisations for Scenario C

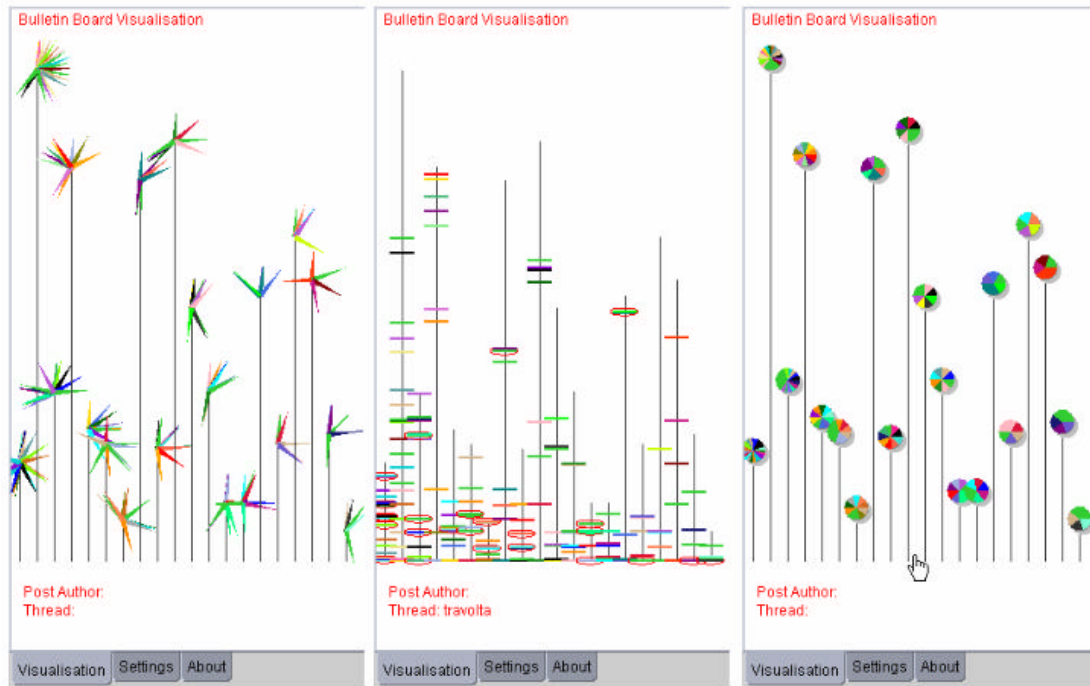


Table 6.40 shows the users' score in completing this task, along with the time taken to complete the task and the number of mouse clicks used.

Table 6.40: Wilcoxon Signed Ranks Test for BulB Data (Scenario C)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Score	2.0	0.75	3.0	0.00	-3.906 ⁱ	<0.0005
Time	107.0	90.00	30.5	43.50	-3.921 ⁱⁱ	<0.0005
Clicks	10.0	6.00	4.0	2.00	-3.663 ⁱⁱ	<0.0005

Again, all users scored a maximum 3 out of 3 when completing this type of task with the aid of visualisations. Without visualisations, users had a median score of 2, with an IQR of 0.75. This difference was significant at the $p < .05$ level, meaning that the use of visualisations helped users get a higher score when there were attempting to identify stagnant threads. The median time taken to complete the task with visualisations was 30.50 seconds, compared to a higher median time of 107 seconds to complete the tasks without the aid of visualisations. Again, this difference was significant. The number of mouse clicks used to complete this task was also lower when using the visualisations, resulting in a significant difference. A median of 4

clicks were used to complete the task using visualisations, compared to 10 clicks without the aid of visualisations.

For this type of task, the visualisations helped users complete the task more accurately and in a more efficient manner. Therefore, the null hypothesis that visualisations do not help in completing this type of task can be rejected with 95% confidence.

Table 6.41 shows the Friedman two-way ANOVA test for the ratings given to the three visualisations for this scenario.

Table 6.41: Friedman Two-way ANOVA for BulB Visualisations (Scenario C)

	Visualisation			Chi-Square	P
	Flower	Pie	Timeline		
Median	4.0	2.0	5.0	33.263	<0.0005
IQR	1.00	1.00	0.00		
Mean Rank	2.30	1.00	2.70		

Given that the Friedman test showed that there was a significant difference between the users' ratings of the three visualisations for this task, Wilcoxon signed ranks tests were carried out to investigate the source of the difference (see Table 6.42).

Table 6.42: Wilcoxon Signed Ranks Tests for BulB Visualisations (Scenario C)

	Wilcoxon Z Statistic	P
Flower v Pie	-4.008 ⁱ	<0.0005
Flower v Timeline	-2.065 ⁱⁱ	0.039
Pie v Timeline	-4.089 ⁱⁱ	<0.0005

The Pie visualisation did not score as highly as either the Flower or Timeline visualisations for this type of task. This resulted in a statistically significant difference between the ratings of the Pie visualisation and the other two visualisations. Interestingly, the Pie visualisation scored poorly for this type of task, providing little added value to the users with a median rating of 2. Although the Pie visualisation shows the spread of individual contributors both in and across the threads, the fact that posts are grouped together in a Pie means that users are unable to see the actual temporal development of the thread and discern when messages

were actually posted. This would explain why users preferred to use the Flower or Timeline visualisations for this type of task.

There was also a significant difference between the Flower and Timeline visualisations, with users finding the Timeline visualisation more useful in completing the task than the Flower visualisation. Therefore, for this particular task, there was a significant difference between all three visualisations, with the Timeline visualisation being favoured most, followed by the Flower visualisation and then the Pie visualisation.

Users preferred the fact that the Timeline draws echelons along the length of the thread rather than simply at the top of the stalk. This makes it easier to determine when posts have been made throughout the history of the thread, with large ‘blank’ areas higher up towards the top of the thread indicating a paucity of recent responses.

Table 6.43 shows the users’ responses to the Likert scale questions for the third scenario.

Table 6.43: Wilcoxon Signed Ranks Test for BulB Task Questionnaires (Scenario C)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Easy to get started	4.5	1.75	5.0	0.00	-2.877 ¹	0.004
Easy to complete	4.5	2.00	5.0	0.00	-2.701 ¹	0.007
Sufficient time	5.0	1.00	5.0	0.00	-2.264 ¹	0.024
Satisfied with results	4.0	2.00	5.0	0.00	-3.104 ¹	0.002
Enjoyable task	5.0	1.00	5.0	0.00	-2.271 ¹	0.023

Across all five questions, there was a significant difference between the responses that users gave with the visualisations, compared to the responses without the aid of visualisations. This shows that users thought that the visualisations helped them complete this task. Not only did users find it easier to get started on questions with the aid of visualisations, but they also found it easier to complete the tasks and do so in a quicker time by using the visualisations. Users were also more satisfied with their results when completing tasks with the aid of visualisations, and they found the tasks more enjoyable when using the visualisations.

6.7.5 Scenario D

For the final type of bulletin board task, users were asked to consider recently active threads and identify the three threads which had been going for the longest period of time. Figure 6.8 shows the views of the three different visualisations for this task.

Figure 6.8: BulB Visualisations for Scenario D

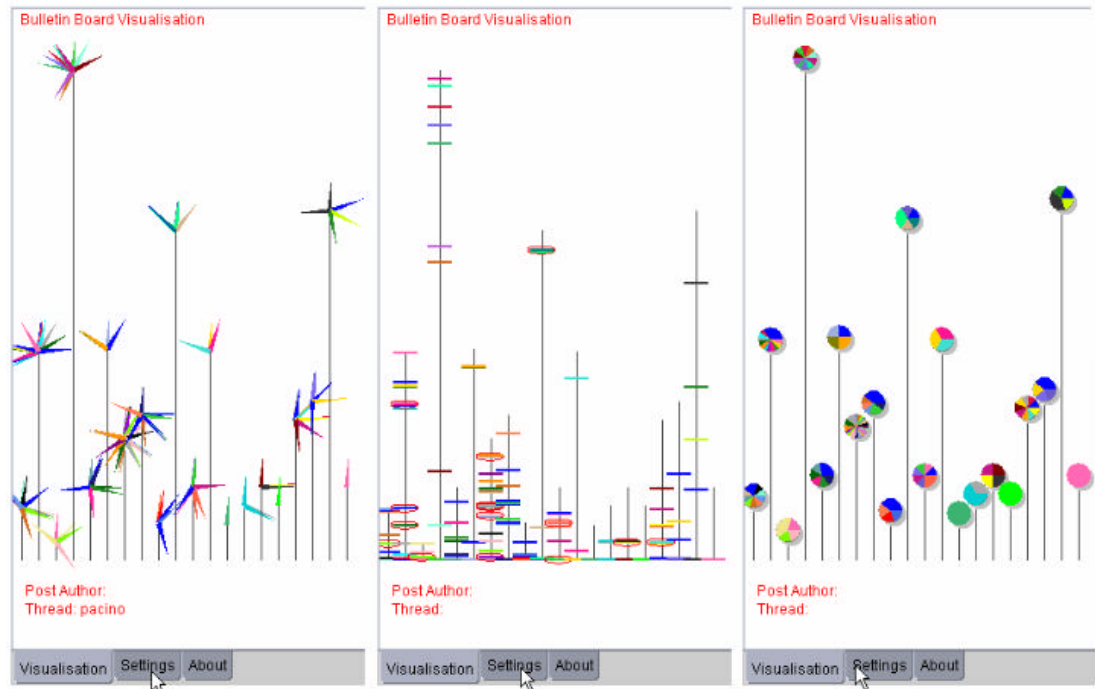


Table 6.44 shows the users' score in completing this task, along with the time taken to complete the task and the number of mouse clicks used.

Table 6.44: Wilcoxon Signed Ranks Test for BulB Data (Scenario D)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Score	3.0	1.00	3.0	0.00	-2.828 ⁱ	0.005
Time	70.0	32.75	21.0	23.75	-3.137 ⁱⁱ	0.002
Clicks	6.0	3.75	4.0	4.00	-2.661 ⁱⁱ	0.008

As was the case with the previous three scenarios, all twenty users scored a maximum 3 out of 3 when completing this type of task with the aid of visualisations. Without visualisations, users had a median score of 3, with an IQR of 1. This

difference was significant at the $p < .05$ level, meaning that the visualisations helped users identify threads which had been active for a long period of time. The median time taken to complete the task with visualisations was 21 seconds, compared to a higher median time of 70 seconds without the aid of visualisations. Again, this difference was significant. The difference between the number of mouse clicks used to complete the task was also significant. A median of 4 clicks were used to complete the task using visualisations, compared to 6 clicks without the aid of visualisations.

For this type of task, the visualisations helped users complete the task more accurately and in a more efficient manner. Therefore the null hypothesis that visualisations do not help in completing this type of task can be rejected with 95% confidence.

Table 6.45 shows the Friedman two-way ANOVA test for the ratings given to the three visualisations for this scenario.

Table 6.45: Friedman Two-way ANOVA for BulB Visualisations (Scenario D)

	Visualisation			Chi-Square	P
	Flower	Pie	Timeline		
Median	4.0	5.0	5.0	15.350	<0.0005
IQR	1.00	1.00	0.00		
Mean Rank	1.58	1.98	2.45		

Since the Friedman test returned a significant difference between the users' ratings of the three visualisations for this task, Wilcoxon signed ranks tests were carried out to investigate the source of the difference (see Table 6.46).

Table 6.46: Wilcoxon Signed Ranks Tests for BulB Visualisations (Scenario D)

	Wilcoxon Z Statistic	P
Flower v Pie	-1.667 ⁱⁱ	0.096
Flower v Timeline	-3.464 ⁱⁱ	0.001
Pie v Timeline	-2.333 ⁱⁱ	0.020

There was a significant difference when comparing the Timeline visualisation against both the Flower and Pie visualisations for this final scenario. This was because the users gave higher ratings to the Timeline visualisation than they did to

the other two visualisations. There was, however, no significant difference between the ratings given to the Flower and Pie visualisations. This indicates that users preferred to use the Timeline visualisation to find threads which had been active for a long period of time with neither the Flower nor Pie visualisations being as useful. Despite not being as highly favoured as the Timeline visualisation for this task, both the Flower and Pie visualisations still received positive feedback from users.

This is an interesting result given that this scenario only requires users to look at the relative height of each thread in order to see how long each thread has been active. Although the height of individual threads is the same across all three visualisations, users responded that they found it easier to judge the height from the Timeline visualisation. This may be because the top of each stalk is blank in the Timeline visualisation (i.e. there is no Flower or Pie drawn there).

Table 6.47 shows the users' responses to the Likert scale questions for the final bulletin board scenario.

Table 6.47: Wilcoxon Signed Ranks Test for BulB Task Questionnaires (Scenario D)

	No Visualisation		Visualisation		Wilcoxon Z Statistic	P
	Median	IQR	Median	IQR		
Easy to get started	5.0	1.00	5.0	0.00	-2.530 ¹	0.011
Easy to complete	4.5	1.00	5.0	0.00	-2.511 ¹	0.012
Sufficient time	5.0	0.75	5.0	0.00	-2.236 ¹	0.025
Satisfied with results	5.0	1.00	5.0	0.00	-2.165 ¹	0.030
Enjoyable task	5.0	1.00	5.0	0.00	-2.121 ¹	0.034

For all five questions, there was a significant difference between the responses that users gave with the visualisations, compared to the responses without the aid of visualisations. Not only did users find it easier to get started on questions with the aid of visualisations, but they also found it easier to complete the tasks and do so in a quicker time by using the visualisations. Users were also more satisfied with their results when completing tasks with the aid of visualisations, and they found the tasks more enjoyable when using the visualisations.

6.7.6 Post-System Questionnaire

As was the case with the matching interest system, users were asked to complete a post-system questionnaire after completing all of the bulletin tasks both with and without the aid of visualisations. Users completed a set of semantic differentials on how they found using the bulletin board system. Table 6.48 shows the subjects' attitude towards the pairs of descriptors on a five-point scale. The table presents the median, IQR, minimum and maximum scores for each of the semantic differential pairs and for the overall differential score.

Table 6.48: Post-test View of the BulB Visualisations

Differential	Median	IQR	Min	Max
Simple	4.0	2.00	2	5
Reliable	5.0	1.00	4	5
Interesting	5.0	1.00	4	5
Attractive	5.0	1.00	3	5
Informative	5.0	1.00	4	5
Relevant	5.0	1.00	3	5
<i>Overall</i>	<i>27.5</i>	<i>4.00</i>	<i>22</i>	<i>30</i>

Overall, users were positive about the bulletin board visualisations with a median score of 27.50 across all the differential pairs. The only semantic differential pair that did not have a median score of 5 was 'simple'/'complex', which still had a median of 4. As was the case with the matching interest visualisations, users believed that the bulletin board visualisations provided information that was interesting, informative and relevant to the tasks they were carrying out, and did so in a reliable manner. The visualisations were also found to be aesthetically pleasing and attractive to users, presenting information in a simple manner.

Users then completed a series of five-point Likert scale questions on the usability of the various bulletin board visualisations. An analysis of these questions is shown in Table 6.49.

Table 6.49: Post-test BulB Usability Questions

Likert scale question	Median	IQR	Min	Max
Easy to learn to use	4.0	1.00	3	5
Easy to use	5.0	1.00	4	5
Understand how to use	4.5	1.00	4	5
Easy to assess usefulness	4.5	1.00	3	5
Intuitively understand visualisations	4.0	1.00	3	5
No further explanation necessary	5.0	1.00	3	5

For each of the six Likert scale questions, the median response given by users was between 4 and 5. Users found the bulletin board visualisations easy to use with no further explanation necessary as they full understood how to use the visualisations. Furthermore, users found that it was easy to learn to use the visualisations, and it was easy to assess the usefulness of something by looking at the visualisations as they intuitively understood the data being depicted by the visualisations.

Users were then asked to rate the three different bulletin board visualisations across all the tasks they carried out. Table 6.50 shows the Friedman two-way ANOVA test for the ratings given to the three visualisations.

Table 6.50: Post-test Friedman Two-way ANOVA for BulB Visualisations

	Visualisation			Chi-Square	P
	Flower	Pie	Timeline		
Median	4.5	4.0	4.0	18.000	<0.0005
IQR	1.00	2.00	1.00		
Mean Rank	2.45	1.33	2.23		

The Friedman test shows that there was a significant difference between the users' ratings of the three visualisations across all bulletin board tasks. In order to identify the source of the difference, Wilcoxon signed ranks tests were conducted (see Table 6.51).

Table 6.51: Post-test Wilcoxon Signed Ranks Tests for BulB Visualisations

	Wilcoxon Z Statistic	P
Flower v Pie	-3.477 ⁱ	0.01
Flower v Timeline	-1.069 ⁱ	0.285
Pie v Timeline	-2.976 ⁱⁱ	0.003

There was a significant difference when comparing the Pie visualisation against both the Flower and Timeline visualisations. This was because the users gave higher ratings to both the Flower and Timeline visualisations than they did to the Pie visualisation. Despite not being as highly rated as the other two, the Pie visualisation still received positive feedback from the users, gaining a median score of 4 across all tasks.

There was, however, no significant difference between the Flower and Timeline visualisations, indicating that users were equally happy to use either of the visualisations across all the bulletin board tasks.

Users then filled out a further series of semantic differentials concerning the information that was presented by the visualisations. Table 6.52 shows the subjects' attitude towards the pairs of descriptors on a five-point scale.

Table 6.52: Post-test View of the Information Provided by BulB Visualisations

Differential	Median	IQR	Min	Max
Timely	5.0	1.00	4	5
Simple	4.0	3.00	2	5
Structured	5.0	1.00	4	5
Clear	5.0	1.00	3	5
Informative	5.0	1.00	4	5
Unobtrusive	5.0	0.75	3	5
<i>Overall</i>	<i>27.0</i>	<i>6.75</i>	<i>20</i>	<i>30</i>

Overall, users were positive about the way that the bulletin board visualisations presented information to them. The only semantic differential pair that did not have a median score of 5 was 'simple'/'complex', which still had a median score of 4.00. Users found that the visualisations presented information in a timely manner that was simple and structured. The information was also found to be clear and informative, accessible in an unobtrusive fashion to the users. The largest variation in scores came when users were asked whether the information provided by the bulletin board visualisations was 'simple'/'complex'. However, this did not impact on the positive ratings given to the other differential pairings.

As with the bulletin board system, users then completed a series of Likert-scale questions on the usefulness of the bulletin board visualisations. An analysis of these questions is shown in Table 6.53.

Table 6.53: Post-test View of Usefulness of BulB Visualisations

Likert scale question	Median	IQR	Min	Max
Trust the visualisations	5.0	1.00	3	5
Easier to complete tasks	5.0	0.75	4	5
Would use visualisations again	5.0	1.00	4	5

For each of the three Likert scale questions, the median response from users was 5. Users trusted the visualisations and found that it was easier to complete the tasks with the aid of the visualisations. They also responded that they would use the visualisations again in the future.

6.8 Summary

This chapter has presented and analysed the results of the various experiments carried out on both the matching interest and bulletin board visualisations. The results have been extremely favourable for both systems, showing that visualisations help users achieve more accurate results when conducting simple information-discovery tasks. Furthermore, visualisations have helped users complete these tasks quicker, meaning that less time would be spent in the information-discovery phase.

Different visualisations have been shown to be more useful in different circumstances, with the strengths of the various visualisations complementing each other across a range of scenarios. The next chapter will consider the results of the experiments within the larger context of this thesis and related literature.

ⁱ Based on negative ranks

ⁱⁱ Based on positive ranks

Chapter 7 Discussion

7.1 Introduction

The previous chapter presented and analysed the results for the user experiments on both the matching interest and bulletin board systems, showing that visualisations helped users to complete simple information-discovery tasks. This chapter will consider these results and discuss them in the context of this thesis and related literature. There will be a focus on the results and how they relate to the various experimental hypotheses before examining the implications of the findings. Limitations of the research will be considered before outlining areas for future work.

7.2 Sustaining Online Communities

While the framework for establishing online communities can be implemented fairly quickly, the creation of successful, self-sustaining online communities is much more difficult and this is highlighted by the large number of failed communities with a dearth of activity, and moribund message boards (Butler, 1999; Kim, 2000; Mohamed et al, 2002). Given that several online communities face problems of withdrawal and attrition, and ultimately fail due to lack of involvement from users, the key challenge lies in encouraging more members to progress from being passive observers towards becoming more active participants who return to the community and contribute on a regular basis.

There is a requirement for instruments that facilitate contributions, raising levels of communication and feelings of kinship in a manner that enables interaction between members and reduces barriers that lead to lack of involvement and community stagnation. Without contributions and exchanges between users, there would be no sense of community. Communication is the core of many online communities, with collective action, exchanges of social support, and sense of community rooted in the conversations that members of the community have with each other (Ginsburg &

Weisband, 2002; Culnan, 2006). In online communities where there is a dearth of active users making contributions, this can ultimately lead to the death of the community as it struggles to attract and retain members. If there are too few contributions in an online community, there will not be sufficient interaction to sustain and maintain the interests of members. A critical mass of activity is required in order to encourage existing members to continue to interact, as well as attract contributions from new or previously passive members (Preece, 2000). Increased participation from users should help towards achieving this critical mass. Therefore, the ultimate aim is to engender a sense of community through repeated social interactions that increase familiarity and strengthen relationships between users.

In attempting to understand and conceptualise the different types of activity that users of online communities can be involved with, this thesis has developed a taxonomy of user objectives (see section 2.7). The content of the taxonomy was based on the common types of tasks normally carried out by users of online communities as outlined by Preece (2000) and Warms et al (2000b). The structure of the taxonomy shows that users tend to take a more passive role at first as they seek to satisfy short-term information-discovery objectives (Preece, 2000). It is only when these short-term objectives are satisfied that they may progress towards becoming more active participants, who contribute and interact with other members (Nonnecke & Preece, 2000; Mager & Karlenzig, 2001). This taxonomy provides a framework for investigating techniques that encourage increased member participation in online communities. It shows the motivation and objectives of users, and highlights the fact that there is a requirement for good facilitation techniques that encourage more users to become active participants.

A rise in contributions from users should create more successful and sustainable online communities, and the use of visualisations has been proposed as a driver towards this goal, through the provision of environments that facilitate and promote social interaction. This thesis has demonstrated that visualisations can be used to reduce the amount of time users spend satisfying short-term objectives in the

information-discovery phase, enabling them to more easily understand and contextualise the activity and interactions within the online community.

Growing maturity in online community systems and technology has dramatically lowered the effort required from members to participate, and when participation is easier, more people participate (Warms et al, 2000b). The results from the user experiments have shown that the use of visualisations aids users in completing the sort of tasks that they frequently undertake as part of their information-discovery phase. In doing so, this reduces the effort required from members before they feel comfortable participating in the community. Given the resulting reduction in the amount of time and effort expended by users in the information-discovery phase, as they seek to satisfy short-term objectives, the use of visualisation have the potential to act as a driver towards increasing social interaction and encouraging contributions from members.

7.3 Suitability of Visualisations

The prevalence of text-based representations within communities makes information-discovery and navigation more difficult due to the lack of social navigation cues. Text-based representations tend to suggest uniformity and ennui rather than the lively social scene which may actually be present within the community (Minar & Donath, 1999; Dieberger et al, 2000; Donath, 2002). Online communities often look and feel abstract and informational rather than inviting for social interaction (Lee et al, 2004), making it difficult to engender a sense of community. The concept of community is normally associated with interaction and shared co-presence, whereas the typical contact between a user and a website is on the whole a solitary experience with limited visual clues indicating the presence of other participants and their activity (Wexelblat, 1999; Dieberger et al, 2000; Svensson et al, 2001). Without visibility of who is around, it is more difficult for social interaction to occur (Jung & Lee, 2000). Extensive user participation is often required in order to get a holistic view of the interaction environment and context. Given that it can be difficult to contextualise the interactions that are taking place, a user's information-discovery phase is often

longer with prolonged membership required in order to find topics of interest and identify the key or leading members of the community (Hattori et al, 1999). The results of the user experiments have shown that the provision of visualisations reduces the amount of time that users spend in the information-discovery phase, thus making online communities more usable. The provision of visualisations helps users get a better understanding of the interaction context and alleviates the problems of information overload that can be prevalent within standard text-based online communities. Visualisations make searching for users and resources of interest easier, and also make browsing bulletin boards easier.

Visual representations of abstract information are valuable in demystifying data and revealing otherwise hidden patterns (Tufte, 1983). They augment human cognition by leveraging human visual capabilities to make sense of abstract information, providing techniques for developing insight and understanding (Card et al, 1999; Heer et al, 2005). A picture is often said to be worth a thousand words, and visualisations can result in a high degree of additional insight into the data they represent, and the provision of interactivity can considerably increase the effectiveness of the visualisation (Spence, 2001).

Visualisations take advantage of human perceptual abilities. People think spatially (Lakoff & Johnston, 1980) and the use of graphical representations can attract viewers and provoke curiosity (Tufte, 1983). A spatially oriented approach through the provision of visualisations to augment online communities takes advantage of this human trait (Boyd et al, 2002), using intuition and perception to amplify cognition and reduce the amount of time spent in the information-discovery phase.

Visual representation of social phenomena is important in the design of successful software to support online communities (Donath, 2002). Visualisation of social activity in an online community aims to create awareness and catalyse social interactions amongst users (Lee et al, 2001), encouraging users to explore and understand the social environment of the online community (Donath et al, 2001).

In developing suitable visualisations, the use of avatars causes problems in terms of screen real estate limitations and they also suffer from a limited range of expressions overlaying users' communications. This means that they fall well short of conveying the subtlety of verbal expressions, or physical gestures, that they sometimes attempt to transmit. As a result the design of both the matching interest and bulletin board visualisations introduced in this thesis focussed on a series of smaller, more abstract visualisations. These abstract graphical representations support social presence and give users a better perspective on community activity. They are easier to produce and manipulate, and persist over time leaving impenetrable traces that are helpful to users (Erickson & Kellogg, 2000). Furthermore, these visualisations take advantage of available technology, making it more powerful, while ensuring universal usability.

Just as the design of an online community requires thought (Kim, 1998; Mager & Karlenzig, 2001), the design of visualisations to support the community needs careful consideration. A key challenge lies in constructing visual metaphors and developing new ways of manipulating existing metaphors to make sense of information (Eick, 2001). Given that people require indicators that allow them to make decisions and interact (Dieberger et al, 2000), any visual aids should enable users to access and assess activities within different functional areas. The matching interest and bulletin board visualisations developed in this thesis have been shown to do this, and the design of both visualisations followed the six claims for visually representing group activity in online environments as laid out by Erickson (2003) (see section 3.4).

Any visualisations must be suitable in terms of helping users, and being fit for purpose. They should not be overly complex or difficult to comprehend from a user's perspective. They should, however, be intuitive, easy to use, easy to access and visually engaging (Donath, 2002). The visualisations must have good usability that enables speed of learning, retention, productivity, user satisfaction, and ensures low error rates (Preece, 2001). Online communities compete with other priorities in the lives of their members. Therefore, any visualisations which augment these communities should make them more usable. The results of the user experiments on the matching interest and bulletin board systems have shown them to be both suitable

and usable, making tasks easier and quicker to do. This is a key factor in encouraging contributions within a community given that the ultimate aim is to reduce the time required before users are happy participating in the community.

Much of the previous research on the use of visualisation within online communities suffers from a series of shortcomings and fails to test the efficacy of the visualisations in helping users undertake common tasks. This thesis has addressed many of these shortcomings by developing more complete and novel visualisations, and has tested the new visualisations in user experiments.

New sets of matching interest and bulletin board visualisations have been developed and introduced as part of this thesis. Matching interest visualisations have been highlighted due to the fact that users of online communities frequently seek to find users and resources of interest during their information-discovery phase. Given that the vibrancy of a community is ultimately dependent upon the conversations that take place between users, visualisations of conversations have also been highlighted, with the primary focus being on bulletin board visualisations given the asynchronous nature of communication that takes place between users of online communities.

In both the matching interest and bulletin board systems, a series of complementary visualisations were developed in order to allow users to view the same data from a range of different perspectives, based on the users' circumstances, needs and requirements. Given that the new visualisations utilise customisable views that give users full control over the functionality and display of the visualisations, this approach enables users to draw more informed conclusions about the suitability and efficacy of specific visualisations in helping to complete certain types of tasks. The efficacy of both the matching interest and bulletin board visualisations will now be discussed in turn.

7.4 Matching Interest

Just as in the real world where people are likely to meet because they have a shared interest, the same is true within online communities. Shared interests help foster a sense of community and enable social groups to emerge. When the collective purpose of the community is in line with the goals of individual members, this helps foster a sense of community and generates social interaction. The provision of matching interest visualisations enables users to see whether their own interests are congruous with the interests of the community and also with other users. Furthermore, given that users will only remain part of a community as long as the community meets their needs better than other alternatives, the provision of matching interest visualisations helps users discover more quickly whether the interests of the community match their own.

Matching interest visualisations are useful in online communities, either suggesting resources that may be of interest, or visualising like-minded users based on previous interactions within the community. Providing these suggestions in the form of a visualisation gives users an overview of other resources and users that match their own history and profile. The provision of matching interest visualisations can act as a driver towards increased levels of interaction and collaboration as users identify people who share similar interests (Hattori et al, 1999; Terveen & McDonald, 2005).

While the majority of existing matching interest visualisations focus on either visualising resources of interest or on visualising other members with similar interests, the new matching interest visualisation, MInt, presented in this thesis provides a set of visualisations that enables users to do both of these. Within an online community, users often seek to find out general information about the community, looking for items of interest and also for other users with similar interests who they may potentially converse with in the future. The use of MInt means that users can easily visualise whether there are resources, or other users, who closely match their own profile.

The results from the user experiments showed that the MInt visualisations were of help to the users in completing each of the four different tasks. Users were able to get a significantly higher score when using the visualisations, they were also able to complete the tasks in a quicker time and they did not need to use as many mouse clicks when completing the questions. Therefore, the null hypothesis that the MInt visualisations do not help users find more accurate information in simple information-discovery tasks can be rejected. Furthermore, the null hypothesis that visualisations do not help users complete these information-discovery tasks in a more efficient manner can also be rejected.

The results also showed that both the Dartboard and Solar visualisations within MInt scored more highly than the Text visualisation across all types of task. This indicates that users preferred a visual representation of the results rather than a textual depiction. Although one user commented that they felt the Solar visualisation was “too dark”, feedback on both the Solar and Dartboard visualisations was extremely positive on the whole and this was reinforced by comments from the open-ended questions in the post-test questionnaire where one user stated that the “Solar and Dartboard visualisations give a good visual representation that makes it a lot easier for me to instantly recognise the best matches”, while another commented that “the Text is okay for reading off the best matches. But I prefer the Dartboard and Solar views since they let me instantly see [the] best matches and allow me to instantly see the distribution of matches. I would definitely use these ones in the future”.

Overall, when considering all four tasks together as a whole, there was no significant difference between the score of the Dartboard and Solar visualisation. Therefore, it is not possible to reject the null hypothesis that no single visualisation is better across all cases tested. There were however significant differences between the scores of the Dartboard and Solar visualisations when considering tasks on an individual basis. This indicates that users prefer to use different visualisations in different circumstances, and that the strengths of the various visualisations complement each other across a range of scenarios. In cases where there are several strong results to

choose from, users preferred the Solar visualisation due to the fact that it draws the results in a more dispersed manner. Conversely, the Dartboard visualisation was preferred for picking out results which were not as strong, and this was also due to the fact that these results were visualised over a wider area, thus making it easier for users to discern the best matches.

This quantitative analysis is also backed up by comments from users. One user stated: “I really like the Dartboard but it can be quite hard to pick out individual results when there are lots of good matches because the icons are all clustered in a small area. The Solar [visualisation] was better for showing really good matches – but less good for worse matches when it can become cluttered.” Another responded: “Solar is good if matches > 80%. For less good matches, the Dartboard is a lot better but good matches can be hard to see in the Dartboard and I think that a zoom function would make it better.”

The feedback from users on the matching interest visualisations was extremely positive and one user commented that “the visualisations definitely make looking at the results a lot easier and I would use them again”. The users found the visualisations useful in completing all types of task and there was good feedback on the visualisations’ usability with users commenting that the visualisations were “very clear”, “easy to understand” and “instantly usable”. Users also indicated that they would have no hesitation in using the visualisations again in the future.

7.5 Bulletin Board

Communication and exchanges between members lie at the heart of online communities, and the vibrancy of a community is ultimately dependent upon the conversations that take place between users. Without contributions and exchanges between users, there would be no sense of community. Given that the sense of community is rooted in the conversations that members of the community have with each other, it is important to provide a visual depiction of these exchanges.

Within existing text-based representations of bulletin boards, information overload is a key problem and the temporal development of conversation can sometime be difficult to identify. This makes it time-consuming for users to browse through large numbers of threads in order to find topics of interest. The provision of visualisations to augment existing bulletin boards can alleviate these problems, providing the means to quickly and easily comprehend the structure and content of conversation archives in ways that make it easier to understand the social environment and grasp the nuances of evolving relationships.

Existing approaches to visualising online conversations tend to either show the temporal development of conversations, or focus on individual participants and their activities. The new bulletin board visualisation, BulB, presented in this thesis improves on these existing approaches by adopting customisable views to both visualise the temporal development of discussions, and also identify participants and their patterns of interaction. In addition to visualising the overall social interaction context, BulB provides a visualisation of the activity of the various contributors in these conversations. In doing so, BulB visualises a wide range of information that depicts the milieu, people and activity within bulletin boards. The visualisations can be used to trace threads, find active posters and identify communication patterns in and across threads, and also between users.

BulB gives an overview of the interaction context. It saves users the effort of browsing all previous bulletin board content and instantly gives users a snapshot of previous activity. The use of customisable views means that users can filter and see details on demand. Users can instantly see which threads have been active for longer, which threads have amassed a greater number of posts, and also which contributors are dominant posters both in and across threads.

The results from the user experiments showed that the BulB visualisations were of help to the users in completing each of the four different bulletin board tasks. Users were able to get a significantly higher score when using the visualisations, they were able to complete the tasks in a quicker time and they did not need to use as many

mouse clicks when completing the questions. As was the case with the MInt visualisations, the null hypothesis that the BulB visualisations do not help users find more accurate information in simple information-discovery tasks can be rejected. Furthermore, the null hypothesis that visualisations do not help users complete these information-discovery tasks in a more efficient manner can also be rejected.

No individual visualisation was rated better or worse across each of the individual tasks. Therefore, it is not possible to reject the null hypothesis that no individual bulletin board visualisation is better in all the cases tested. Rather, the usefulness of individual visualisations depends upon the needs and requirements of the user, based upon the task that they are carrying out at any given time. In fact, one user actually commented: “The visualisations each have their own merits and all were needed for different questions.”

When considering the four tasks together as a whole, there was a significant difference between all three visualisations. Therefore, the null hypothesis that no particular BulB visualisation is any more helpful in conducting simple information-discovery tasks can be rejected. The Timeline visualisation was rated the most useful, followed by the Flower, and then the Pie visualisation. However, this finding is contradicted by the responses given by users in the post-test questionnaire where there was no significant difference between the rating given to the Timeline and Flower visualisations. When looking back on the tasks as a whole, users perceived that both the Timeline and Flower visualisations were more useful than the Pie visualisations in helping them do all types of task. The higher ratings given to the Flower and Timeline visualisations are borne out by comments from users who stated: “the Timeline and Flower were more useful for the majority of tasks”, and “I found that I used the Flower and Timeline visualisations more than the Pie”.

Despite being rated the least useful when considering all four tasks as a whole, it is important to note that for the first type of task, where users were asked to identify dominant users in the bulletin board, the Pie visualisation was rated the most useful BulB visualisation for this specific scenario. These findings are further supported by

comments from users who stated: “although I found the Flower and Timeline more useful overall, the Pie was most useful in spotting users with the most posts”, and also: “unlike the other questions, I prefer to use the Pie when looking for dominant users because it makes it easier to see their share of posts in multiple threads”.

These results show that in cases where users are looking at the temporal development of threads, they find the Flower and Timeline visualisations more useful. Whereas in cases where users are trying to identify the share of posts made by individual contributors in and across threads, the Pie visualisation is more effective. Once again, this points to the fact that the strengths of the various visualisations complement each other across a range of scenarios, and the efficacy of different visualisations varies dependent upon the type of task being undertaken.

Overall, the feedback from users on the bulletin board visualisations was extremely positive. Comments from users included: “I found them [the visualisations] very useful indeed”, “very helpful”, “visualisations are excellent and help a lot” and “the visualisations definitely make browsing the bulletin board a lot easier and I would certainly use them in the future”. The users found the visualisation useful in completing all types of task and there was good feedback on the visualisations’ usability and suitability. One user stated: “They [the visualisations] are very unobtrusive and don’t interfere with what you are doing. Despite showing a lot of data, they are not overly complex and are very easy to understand.” Interestingly, another user commented: “The visualisations are very good and don’t intrude on the interaction. I think they would encourage me to browse more as I see the structure of different threads, and this may make me more likely to stumble across something of interest.” As was the case with the MInt visualisations, users indicated that they would like to use the BulB visualisations again in the future.

7.6 Usefulness of Visualisations

From the results, the overall conclusion that can be reached is that visualisations help users in completing simple information-discovery tasks, with different visualisations

helping for different types of task. However, there is no single visualisation that is more helpful to users in all circumstances tested.

While the MInt and BulB visualisations helped users complete the tasks in the experiments, this does not necessarily mean that visualisations per se are the answer to creating more successful and sustainable online communities. Any visualisation that is used must consider the needs of the community and the context in which the visualisation will be used. The use of certain visualisations may not add any value whatsoever and in some circumstances the use of visualisations which are full of unnecessary embellishments and chartjunk may merely be a distraction, detrimentally harming the user's experience (Tufte, 1983). While the testing of MInt and BulB was a success, the results of the experiments point to the fact that the needs and requirements of the community must be analysed in full when considering what type of visualisation, if any, would be of benefit to users.

The results from the user experiments have shown that different visualisations are more useful in different circumstances. Therefore, it is not possible to say that any individual visualisation is the answer. There is no magic bullet that can help in all circumstances. As was the case with both MInt and BulB, a range of visualisations that complement each other should be provided so that users can choose the most suitable and appropriate visualisations for the given task that they are undertaking.

There may also be circumstances in which the usefulness of visualisations may be dependent upon the demographic spread of the community. For example, visualisations may be of more use to new members in helping them get up to speed with the community. A common problem faced by new users is that they are susceptible to being flamed for asking common frequently asked questions (Soroka et al, 2003; Preece et al, 2004). The utilisation of visualisations may help users in identifying bulletin board threads where specific points may have been previously raised.

Similarly, visualisations may also be more helpful for users who are infrequent visitors to communities. Through the use of visualisations, such users may find it easier to catch up on events from the period in which they have been dormant. It may also apply that frequent visitors to communities may have less need for visualisations since they already know what is happening within the community. However in order to test the validity of such theories, further longitudinal study of the use of visualisations within communities would be necessary and this is discussed in section 7.8.

7.7 Limitations

Of the twenty test subjects who took part in the final experiments, there was a lack of truly inexperienced users of online communities, with only one user who was not a member of any online communities at all. It may have been beneficial to carry out experiments where half of the test subjects were experienced users of online communities and half were inexperienced. However, as discussed in section 5.5, this was not possible due to the limited number of people who volunteered to take part in the experiments.

Despite the fact that there was a paucity of novice test subjects, only 45% of the users who took part in the experiments categorised themselves as active members of online communities, meaning that there was still a wide spread of users with different levels of experience in using online communities. Irrespective of their prior level of activity within online communities, the users who took part in the experiments found the visualisations to be helpful in completing tasks. Nonetheless, further work is required to investigate whether certain visualisations would help more inexperienced users and this is considered in the next section.

As outlined in Chapter 5 rather than carrying out the tests in an active online community, the experiments were carried out in a laboratory setting. In carrying out the experiments, the study was based upon a model of the real world, with the selection of people and tasks made so that it was amenable to the use of experiments.

There are obvious limitations in the use of a model environment rather than carrying out a study over a longer period of time using active online communities. There were a limited number of tasks for the users to carry out in a limited period of time, meaning that it was not possible to test the efficacy of the visualisations in a broader range of scenarios. There were also only three different types of visualisation for each system, and a total of only twenty test subjects taking part in the experiments. Furthermore, the ratings given to the visualisations in the experiments relied on self-reporting from users. Although care was taken in the design of the experiments, this form of self-reporting relies upon users answering questions truthfully, and users may have a natural predisposition within experimental settings to give favourable comments about innovative methods such as the visualisations presented in the study.

Despite these caveats, the experimental model provided a good approximation of the real world since there are many similarities between the tasks in the experiments and the types of task which people do in 'real world' online communities. The chosen experimental tasks were based upon the taxonomy of user objectives that was introduced in Chapter 2, and are representative of the type of tasks normally carried out by users of online communities as outlined by Preece (2000) and Warmus et al (2000b). The validity of the tasks was further backed up by feedback from experimental users who stated that "the visualisations are very useful indeed and helped in finding the sort of information I usually look for", and also that they "would use the visualisations in the future as they make searching a lot easier".

While both the MInt and BulB visualisations received positive feedback and helped users in completing the experimental tasks, the visualisations as they currently stand would not scale up to support a large community of several hundreds of threads and users due to screen real estate limitations. Given that the visualisations are shown as an applet which acts as an augmentation on the side of each page, this means that there are issues of space which impose limitations on the amount of data which can be shown. The use of a magnifying glass or zoom feature would alleviate this and support a larger community, and this is discussed further in the next section.

7.8 Future Work

The work undertaken as part of this thesis has highlighted several avenues for future research which would build on the current findings. As already discussed, the results presented in the previous chapters are based on experiments which took place in laboratory settings. Therefore, further longitudinal evaluation of the visualisations in an active online community would enable testing of the visualisations over a longer period of time, and also across a wider range of scenarios. Although users indicated as part of their feedback that they would use the visualisations in the future, these results were largely based on self-reporting from users and further longitudinal evaluation would test whether users do actually prefer to use the visualisations over an extended period of time. Observation of the use of the visualisations in this manner would also enable the development of a wider set of visualisations which may prove more useful than the ones developed in this thesis.

Launching the visualisations in an active online community would facilitate the study of how the visualisations are used by a larger number of users, and also by different types of users. This would enable the examination of whether the visualisations tend to be used more often by experienced or inexperienced users. There may also be differences in how the visualisations are used by different types of online community, and introducing the visualisations to a range of different online communities would enable testing of whether the domain of interest has any impact on the usage patterns of the visualisations.

Within standard text-based online communities, vast numbers of participants and messages can make it difficult to comprehend the interaction context, track user participation, and understand the social connections within the community (Zhang & Lee, 2002). Since the information-discovery phase can be elongated in large communities with high traffic and lots of new messages, it would also be interesting to study whether visualisations are especially useful in larger communities, alleviating the problems caused by having too many messages to sort through.

As discussed in section 2.8.4, the principle of time elasticity within an online community means that as the amount of time required to participate in the community decreases, contributions should increase. The deployment of the visualisations within an active online community would enable the testing, over an extended period of time, of whether the use of visualisations does actually shrink the amount of time that users spend in the information-discovery phase. In turn, this would facilitate the examination of whether less time spent in the information-discovery phase, as a direct result of the use of visualisations, actually results in a higher percentage of users becoming more active participants in the community. Such tests would investigate whether the provision of visual representations supports social interaction between members of online communities by acting as a driver towards higher levels of contributions. The challenge lies in encouraging users to progress towards satisfying more medium and long-term objectives by making contributions and becoming more active members of the community.

Given that many online communities fail due to lack of involvement from users, if visualisations can be shown to act as a driver towards raised levels of contributions over an extended period of time, this will have wide-reaching implications for the future sustainability of online communities. Allied to this, the use of visualisations may also have a positive impact on general levels of activity within online communities, with members who were previously content to be passive and lurk in the background now encouraged to post messages and become more active participants. However, in order to test these theories, further longitudinal study of the visualisations is required.

Feedback from users who took part in the experiments has also highlighted a range of possible enhancements which could be implemented in future versions of the visualisations. Several users indicated that they would like to see a zoom feature in the visualisations so that they can get a clearer view of areas on the visualisations where there is a cluster of activity. For example, in the Dartboard visualisation within MInt, this would enable users to zoom in on the centre of the target to get a clearer

view of clusters of particularly good results. A zoom feature would also be valuable within BulB, providing a close-up view of Flower heads, thus enabling users to see more clearly how an individual thread has developed, and zooming in on hotspots within the Timeline visualisation would enable users to see more detailed information about particularly busy periods in threads, thus reducing problems caused by too many messages being drawn in a small area. Users also suggested that they would like to see a summary of their current settings listed at the bottom of the visualisations so that they did not have to switch back to the settings tab in order to confirm what the current settings are.

Specifically for the Solar visualisation within MInt, a couple of users requested that the colour of icons be graded in order to make it easier to discern the percentage match without having to mouse over individual icons in order to see this detail. This would enable users to quickly get a feel for the distribution of results in a similar fashion to that currently provided by the different coloured bands in the Dashboard visualisation.

The provision of a slider or scroll bar along the bottom of the BulB visualisations was also requested in order to enable more threads to be visualised at one time, and users also requested added functionality that would enable them to 'tag' different threads that could then be combined and visualised separately.

Through the addition of extra functionality, the visualisations can continue to evolve, responding to users' needs, taking a community-centred design approach towards the continued development of visualisations that are both more suitable and more usable. The deployment of the visualisations in active online communities would also result in further suggestions for enhancements to the visualisations which could be implemented in future versions of the systems. Therefore, it is vital that more work is undertaken to further this imaginative research, testing these concepts further in active online communities and through longitudinal user studies.

7.9 Summary

This chapter has considered the experimental results within the context of this thesis and related literature. For both the matching interest and bulletin board systems, the experimental hypotheses have been considered across all the experimental tasks. The implications of the findings, in terms of the general usefulness of visualisations within online communities have been discussed, before considering the limitations of this research. Finally, areas for future work which build on this novel research have been outlined, detailing ways in which the additional work can further contribute to knowledge.

Chapter 8 Conclusion

8.1 Overview

This concluding chapter summarises the main findings of this thesis, reviewing the original hypotheses of this research before restating the contributions of this work and the ramifications of the findings.

This thesis has investigated a wide range of issues relating to the sustainability and growth of online communities. The process of discovering information and understanding the interaction context within online communities can be a time-consuming task, especially for new or inexperienced users, meaning that many members often take a passive role. Ultimately, numerous online communities fail due to lack of involvement from users who are content to lurk, playing a passive role in the community (Butler, 1999). Given the dynamics of community interaction that have been highlighted in this thesis, visualisations have been identified as a potential source of benefit to users of online communities.

The visualisations developed in this thesis provide facilitation techniques that support users of online communities. They have the potential to act as a driver, enabling users to become more active participants through increased levels of contributions. They present contextual information to users and have been shown to assist in completing a range of simple information-discovery tasks. The experimental results demonstrate that the visualisations enable users to meet their short-term interaction objectives in a more timely and efficient manner. Both MInt and BulB visualise information through the use of customisable displays that have proven to be meaningful, suitable, usable and understandable.

8.2 Review of Hypotheses

In carrying out experiments on both the matching interest and bulletin board systems, three main hypotheses were tested. The null hypotheses of these were as follows:

Hypothesis 1

H₀: Visualisations do not help users of online communities find more accurate information in simple information-discovery tasks

Hypothesis 2

H₀: Visualisations do not help users of online communities to complete information-discovery tasks in a more efficient manner

Hypothesis 3

H₀: No particular visualisation is any more helpful in conducting simple information-discovery tasks

Across all tasks in both the matching interest and bulletin board systems, the visualisations were a success, enabling users to find more accurate information and also do so in a more efficient manner. Therefore, the first two null hypotheses were rejected. However, the results of the experiments did not find any individual visualisation in either system to be more useful in completing all tasks, meaning that the final null hypothesis could not be rejected. Rather, different visualisations were found to be more useful for different tasks. These findings show that while the complementary nature of the visualisations offered by MInt and BulB was successful in helping users complete the tasks, the needs and requirements of users, and the tasks they undertake, must be considered when designing the exact nature of any potential visualisations. There should be a community-centred design approach towards the continued development of any visualisations in order to ensure that they are both suitable and usable.

8.3 Contributions of this Thesis

As part of this research, contributions have been made in the following ways:

- **Developed a taxonomy of users' objectives.** Existing research outlined in this thesis highlighted the common objectives and tasks that users of online communities seek to satisfy. This thesis developed this existing work into a taxonomy that highlights and conceptualises the spectrum of different activities that users of online communities can be involved in, ranging from short-term information-discovery objectives through to medium and long-term objectives in which users become more active participants in the community.
- **Demonstrated that visualisations aid users to complete simple information-discovery tasks.** Much of the previous research failed to test the efficacy of their visualisations in helping users carry out simple tasks that would normally be conducted during the use of online communities. This thesis has addressed this shortcoming by testing the visualisations developed herein within a series of user experiments which prove the visualisations to be useful in helping users complete simple information-discovery tasks.
- **Demonstrated that visualisations can be used to reduce the amount of time spent in the information-discovery phase.** This thesis has shown that not only do visualisations help users achieve more accurate results in conducting simple information-discovery tasks, but they also help users complete these tasks in a more efficient manner, thus shrinking the amount of time spent in the information-discovery phase.
- **Demonstrated that different types of visualisation are more useful in different circumstances.** This thesis tested the visualisations developed in the thesis in a range of different circumstances, and the results have shown that the strengths of the various visualisations complement each other, and different visualisations are more helpful for different types of task.

8.4 Summary

This thesis has investigated a number of key issues affecting the growth and sustainability of online communities. The role of visualisations and their suitability in supporting users of online communities has been explored, with a range of new complementary visualisations having been presented and evaluated. The results have proven encouraging, demonstrating that the visualisations developed in this thesis can be used to help users complete common tasks within an online community, and in such a manner that the information-discovery phase should shrink. The results have further shown that the various visualisations complement each other, and that a range of different visualisations are more helpful for different types of tasks. If the results of this thesis can be extended, and visualisations can be shown to act as a driver towards raised levels of contributions over an extended period of time, this will have wide-reaching implications for the future sustainability of online communities. This thesis has shown that visualisations ought not to be seen as an end in themselves, but rather as a means for enabling increased levels of communication within online communities.

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Appendices

Appendix A Experimental Procedure and Instructions

EXPERIMENTAL PROCEDURE AND INSTRUCTIONS

Thank you for agreeing to participate in this experiment. In return, you will be given the opportunity to take part in a prize draw at the end of the session.

The goal of this experiment is to assess how well various visualisations can aid users of online communities. Only the systems are being tested, you are not being tested on how well you complete each task.

You will be using 2 systems in this experiment:

- matching interest
- bulletin board

You should already have made up a brief user profile outlining your main interests in films. Your profile is available on a separate sheet should you need to refer to it at any time

This profile will be used for the **matching interest tasks only**. When completing the matching interest tasks, you are asked to find items that are of interest to you *based on this profile*.

For each system, you will be asked to complete 8 brief tasks in total. These tasks will be split in half as follows:

- 4 will be aided by a set of visualisations
- 4 without the aid of any visualisations

Given the simple nature of the tasks, you will be given a maximum of 4 minutes to complete each task. You will be told when the time limit for each task is complete. Please inform me when you have started and completed each individual task.

Prior to using each system in this experiment, you will be given a demonstration of how the system works. You will then have 5 minutes thereafter to familiarise yourself with the system and visualisations. You may ask for clarification on how the system works at any time

You will also be asked to complete the questionnaires as follows:

- Before the experiment
- After each task
- After using each system

The experiment will be recorded and last for approximately 2 hours. At any point in the experiment, you may ask for clarification on the individual tasks, experimental instructions or on how the system works.

Data Protection

All data collected for the purposes of this experiment will be anonymised to ensure that it cannot be attributed to a particular individual. The data will be retained for a period of 6 months after the completion of the project and will not be supplied to third parties.

Signed:_____

Date:_____

Appendix B Pre-Test Questionnaire

ENTRY QUESTIONNAIRE



This questionnaire will provide background information that will be used to analyse the answers you give in later stages of this experiment.

Where applicable, place a TICK in the square that best matches you.

Section 1: PERSONAL DETAILS

1. Please provide your AGE:

2. Please indicate your GENDER:

Male..... 1

Female..... 2

3. Please indicate the HAND YOU USE TO CONTROL THE MOUSE:

Right..... 1

Left..... 2

4. Please provide your CURRENT OCCUPATION:

5. Is English your first language?

Yes..... 1

No..... 2

Section 2: ONLINE EXPERIENCE

6. How many years have you been using the Internet?

7. How many Online Communities do you regularly visit? (incl. blogs, bulletin boards, forums etc)? NOTE: IF YOU ANSWER ZERO, PLEASE SKIP TO SECTION THREE


0 1 2 3 4 5 5+

Please list them....

8. How often do you visit these Online Communities?

once or twice a year	once or twice a month	once or twice a week	once or twice a day	more often
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

9. Would you consider yourself an active member of these communities? (posting messages etc.)

Low 

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5

11. What do you use Online Communities for? (mark AS MANY as apply)

educational..... 1

work..... 2

social..... 3


other (please specify)..... 4

10. GENERALLY Your experience in using Online Communities is:

	1	2	3	4	5	
favourable	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Unfavourable
stressful	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Relaxing
interesting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Boring
facile	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Educational
satisfying	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Frustrating

Section 3: EXPERIMENTAL DOMAIN

11. What is your level of interest in movies?


Low 

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5

12. Generally, how often do you watch movies? (on tv, dvd/video or at the cinema)

once or twice a year	once or twice a month	once or twice a week	more often
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

13. Is the profile you made in advance of the experiment an accurate depiction of your tastes?

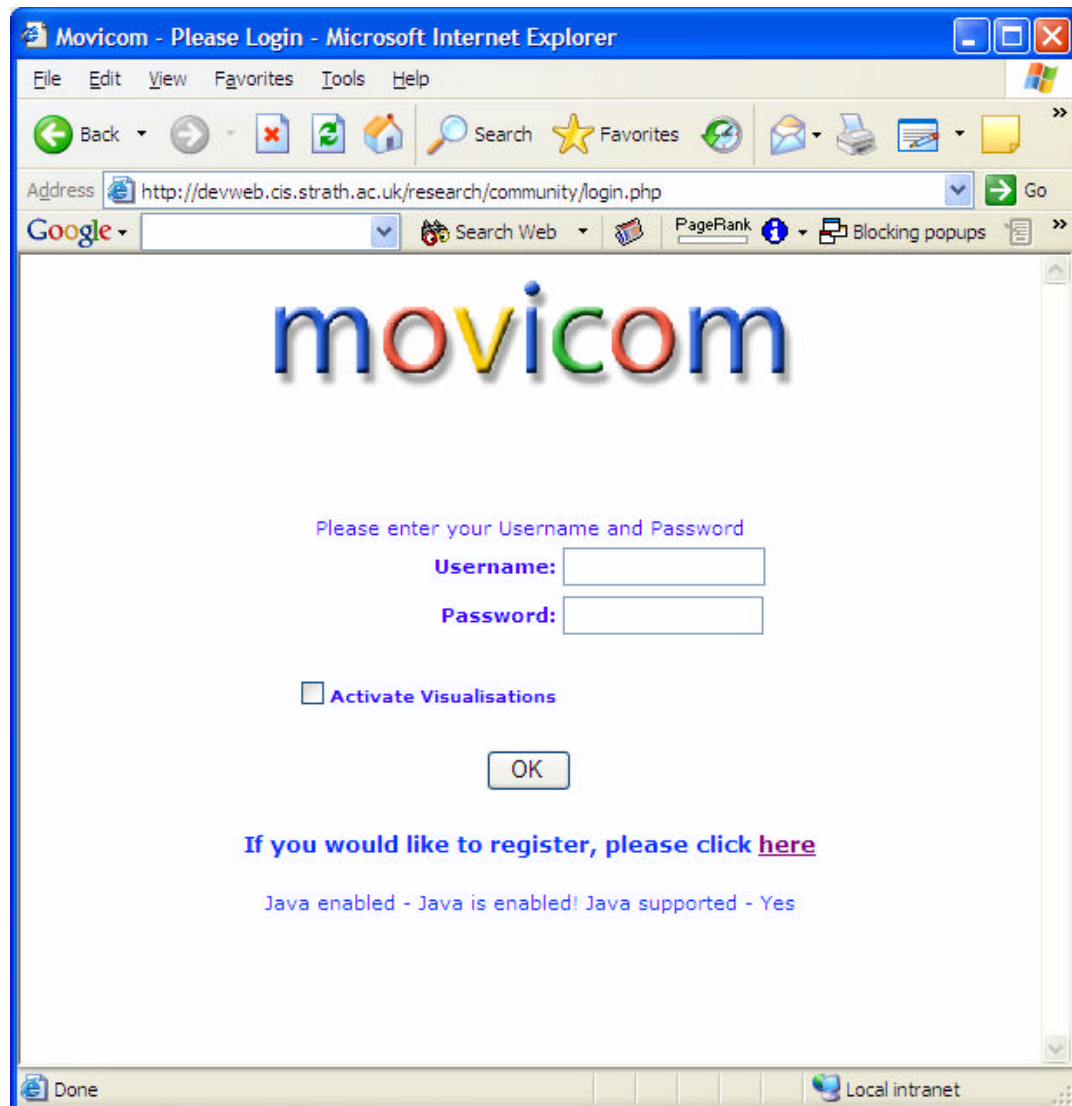
Low 

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5

Appendix C Task Questionnaires

Please open Shortcut 1 from the test folder.

Now log in, making sure that you have selected the checkbox that says *'Activate Visualisations'*






MATCHING INTEREST – TASK A1

Carry out a search for Users. Do an Advanced Search for Users who like films starring 'Robert De Niro. List the 3 users who have the closest match to your profile.

- 1.
- 2.
- 3.

Rate the usefulness of each visualisations in completing this task

	Poor	Excellent		
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5
	Poor	Excellent		
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5
	Poor	Excellent		
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5

Please answer the following questions, as they relate to the task you have just completed.

1. It was easy to get started on this task

Disagree

Agree

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5

2. It was easy to complete this task

Agree

Disagree

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	4	3	2	1

3. I had sufficient time to complete this task

Disagree

Agree

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5

4. I am completely satisfied with my results

Agree

Disagree

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	4	3	2	1

5. This task was enjoyable

Disagree

Agree t

1

2

3

4

5




Other Comments

MATCHING INTEREST – TASK A2

Carry out a search for Users. Do an Advanced Search for Users who like 'War' films. List the 3 users who have the closest match to your profile.

- 1.
- 2.
- 3.

Rate the usefulness of each visualisations in completing this task

	Poor	Excellent			
	<input type="checkbox"/>	<input type="checkbox"/>			
	1	2	3	4	5
	Poor	Excellent			
	<input type="checkbox"/>	<input type="checkbox"/>			
	1	2	3	4	5
	Poor	Excellent			
	<input type="checkbox"/>	<input type="checkbox"/>			
	1	2	3	4	5

Please answer the following questions, as they relate to the task you have just completed.

1. It was easy to get started on this task

Disagree

Agree

1 2 3 4 5

2. It was easy to complete this task

Agree

Disagree

5 4 3 2 1

3. I had sufficient time to complete this task

Disagree

Agree

1 2 3 4 5

4. I am completely satisfied with my results

Agree

Disagree

5 4 3 2 1

5. This task was enjoyable

Disagree

Agree t

1

2

3

4

5




Other Comments

MATCHING INTEREST – TASK A3

Carry out a search for Resources/Films. Do an Advanced Search for 'Action' films. List the 3 films which best match your profile.

- 1.
- 2.
- 3.

Rate the usefulness of each visualisations in completing this task

  	Poor Excellent <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 1 2 3 4 5
	Poor Excellent <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 1 2 3 4 5
	Poor Excellent <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 1 2 3 4 5

Please answer the following questions, as they relate to the task you have just completed.

1. It was easy to get started on this task

Disagree Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 1 2 3 4 5
--
2. It was easy to complete this task

Agree Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 5 4 3 2 1
--
3. I had sufficient time to complete this task

Disagree Agree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 1 2 3 4 5
--
4. I am completely satisfied with my results

Agree Disagree <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 5 4 3 2 1
--

5. This task was enjoyable

Disagree

Agree t

1

2

3

4

5




Other Comments

MATCHING INTEREST – TASK A4

Carry out a search for Resources/Films. Do an Advanced Search for films directed by 'Ridley Scott'. List the 3 films which best match your profile.

- 1.
- 2.
- 3.

Rate the usefulness of each visualisations in completing this task

	Poor	Excellent		
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5
	Poor	Excellent		
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5
	Poor	Excellent		
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5

Please answer the following questions, as they relate to the task you have just completed.

1. It was easy to get started on this task

Disagree

Agree

1 2 3 4 5

2. It was easy to complete this task

Agree

Disagree

5 4 3 2 1

3. I had sufficient time to complete this task

Disagree

Agree

1 2 3 4 5

4. I am completely satisfied with my results

Agree

Disagree

5 4 3 2 1

5. This task was enjoyable

Disagree

Agree t

1

2

3

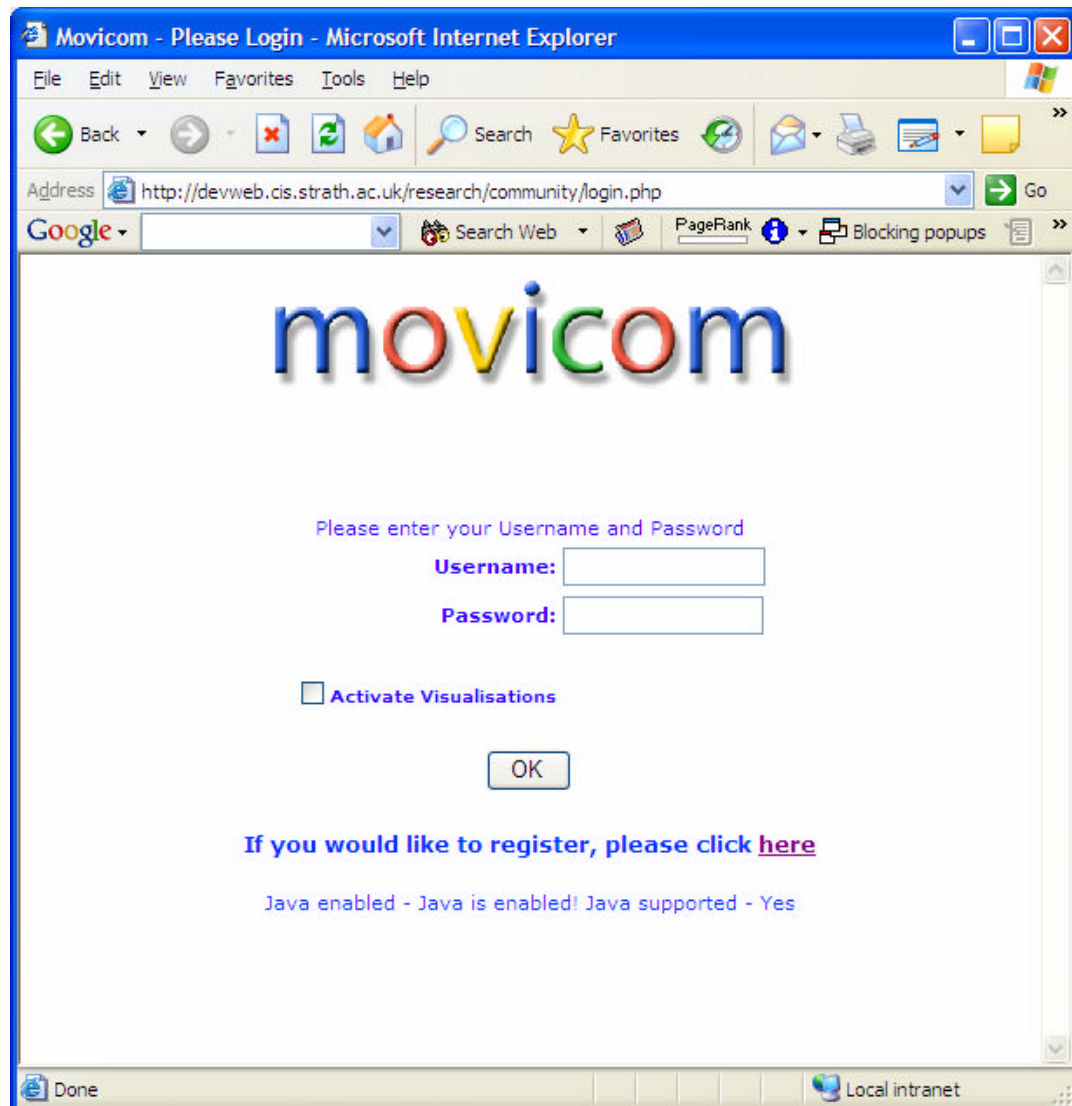
4

5

Other Comments

Please open 'Shortcut 2' from the test folder.

Now log in. Ensure that the checkbox that says '*Activate Visualisations*' is left blank.



MATCHING INTEREST – TASK B1

Carry out a search for Resources/Films. Do an Advanced Search for 'Thriller' films. List the 3 films which best match your profile.

- 1.
- 2.
- 3.

Please answer the following questions, as they relate to the task you have just completed.

1. It was easy to get started on this task
<p>Disagree Agree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>1 2 3 4 5</p>
2. It was easy to complete this task
<p>Agree Disagree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>5 4 3 2 1</p>
3. I had sufficient time to complete this task
<p>Disagree Agree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>1 2 3 4 5</p>
4. I am completely satisfied with my results
<p>Agree Disagree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>5 4 3 2 1</p>
5. This task was enjoyable
<p>Disagree Agree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>1 2 3 4 5</p>
Other Comments

MATCHING INTEREST – TASK B2

Carry out a search for Users. Do an Advanced Search for Users who like films directed by 'Oliver Stone'. List the 3 users who have the closest match to your profile.

- 1.
- 2.
- 3.

Please answer the following questions, as they relate to the task you have just completed.

1. It was easy to get started on this task
<p>Disagree Agree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>1 2 3 4 5</p>
2. It was easy to complete this task
<p>Agree Disagree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>5 4 3 2 1</p>
3. I had sufficient time to complete this task
<p>Disagree Agree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>1 2 3 4 5</p>
4. I am completely satisfied with my results
<p>Agree Disagree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>5 4 3 2 1</p>
5. This task was enjoyable
<p>Disagree Agree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>1 2 3 4 5</p>
Other Comments

MATCHING INTEREST – TASK B3

Carry out a search for Resources/Films. Do an Advanced Search for films directed by 'James Cameron'. List the 3 films which best match your profile.

- 1.
- 2.
- 3.

Please answer the following questions, as they relate to the task you have just completed.

1. It was easy to get started on this task
<p>Disagree Agree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>1 2 3 4 5</p>
2. It was easy to complete this task
<p>Agree Disagree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>5 4 3 2 1</p>
3. I had sufficient time to complete this task
<p>Disagree Agree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>1 2 3 4 5</p>
4. I am completely satisfied with my results
<p>Agree Disagree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>5 4 3 2 1</p>
5. This task was enjoyable
<p>Disagree Agree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>1 2 3 4 5</p>
Other Comments

MATCHING INTEREST – TASK B4

Carry out a search for Users. Do an Advanced Search for Users who like 'Action' films. List the 3 users who have the closest match to your profile.

- 1.
- 2.
- 3.

Please answer the following questions, as they relate to the task you have just completed.

1. It was easy to get started on this task	
Disagree	Agree
<input type="checkbox"/>	<input type="checkbox"/>
1	2
<input type="checkbox"/>	<input type="checkbox"/>
3	4
<input type="checkbox"/>	<input type="checkbox"/>
5	
2. It was easy to complete this task	
Agree	Disagree
<input type="checkbox"/>	<input type="checkbox"/>
5	4
<input type="checkbox"/>	<input type="checkbox"/>
3	2
<input type="checkbox"/>	<input type="checkbox"/>
1	
3. I had sufficient time to complete this task	
Disagree	Agree
<input type="checkbox"/>	<input type="checkbox"/>
1	2
<input type="checkbox"/>	<input type="checkbox"/>
3	4
<input type="checkbox"/>	<input type="checkbox"/>
5	
4. I am completely satisfied with my results	
Agree	Disagree
<input type="checkbox"/>	<input type="checkbox"/>
5	4
<input type="checkbox"/>	<input type="checkbox"/>
3	2
<input type="checkbox"/>	<input type="checkbox"/>
1	
5. This task was enjoyable	
Disagree	Agree
<input type="checkbox"/>	<input type="checkbox"/>
1	2
<input type="checkbox"/>	<input type="checkbox"/>
3	4
<input type="checkbox"/>	<input type="checkbox"/>
5	
Other Comments	

Please open 'Shortcut 3' from the test folder.


Now please log in.

BULLETIN BOARD – TASK A1

Examine the most popular threads. Across *all* these threads, identify the three users who you think have made the most posts throughout the entire history of the bulletin board.

- 1.
- 2.
- 3.

Rate the usefulness of each visualisations in completing this task



Poor					Excellent
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
1	2	3	4	5	

Poor					Excellent
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
1	2	3	4	5	

Poor					Excellent
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
1	2	3	4	5	

Please answer the following questions, as they relate to the task you have just completed.

1. It was easy to get started on this task

Disagree					Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
1	2	3	4	5	

2. It was easy to complete this task

Agree					Disagree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5	4	3	2	1	

3. I had sufficient time to complete this task

Disagree					Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
1	2	3	4	5	

4. I am completely satisfied with my results

Agree					Disagree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5	4	3	2	1	

5. This task was enjoyable

Disagree

Agree t

1

2

3

4

5


Other Comments

BULLETIN BOARD – TASK A2

Examine the most popular threads which have had posts in the last week. From these, identify the three threads with the most posts.

- 1.
- 2.
- 3.

Rate the usefulness of each visualisations in completing this task

	Poor					Excellent
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	1	2	3	4	5	
	Poor					Excellent
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	1	2	3	4	5	
	Poor					Excellent
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	1	2	3	4	5	

Please answer the following questions, as they relate to the task you have just completed.

1. It was easy to get started on this task

Disagree					Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
1	2	3	4	5	

2. It was easy to complete this task

Agree					Disagree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5	4	3	2	1	

3. I had sufficient time to complete this task

Disagree					Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
1	2	3	4	5	

4. I am completely satisfied with my results

Agree					Disagree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5	4	3	2	1	

5. This task was enjoyable

Disagree

Agree t

1

2

3

4

5





Other Comments

BULLETIN BOARD – TASK A3

Examine popular threads with the most posts. Consider *all* popular threads and identify 3 threads which are becoming stagnant with little or no posts made to them recently.


- 1.
- 2.
- 3.

Rate the usefulness of each visualisations in completing this task

	Poor  Excellent
	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
	Poor  Excellent
<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	
Poor  Excellent	
<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	


Please answer the following questions, as they relate to the task you have just completed.

1. It was easy to get started on this task

Disagree  Agree


1 2 3 4 5

2. It was easy to complete this task

Agree  Disagree


5 4 3 2 1

3. I had sufficient time to complete this task

Disagree  Agree

1 2 3 4 5

4. I am completely satisfied with my results

Agree  Disagree

5 4 3 2 1

5. This task was enjoyable

Disagree

Agree t

1

2

3

4

5





Other Comments

BULLETIN BOARD – TASK A4

Examine threads with recent posts. Consider *all* these recently active threads and from these, identify the 3 threads which have been going for the longest period of time.


- 1.
- 2.
- 3.

Rate the usefulness of each visualisations in completing this task

	Poor  Excellent
	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
	Poor  Excellent
<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	
Poor  Excellent	
<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	


Please answer the following questions, as they relate to the task you have just completed.

1. It was easy to get started on this task

Disagree  Agree


1 2 3 4 5

2. It was easy to complete this task

Agree  Disagree


5 4 3 2 1

3. I had sufficient time to complete this task

Disagree  Agree

1 2 3 4 5

4. I am completely satisfied with my results

Agree  Disagree

5 4 3 2 1

5. This task was enjoyable

Disagree

Agree t

1

2

3

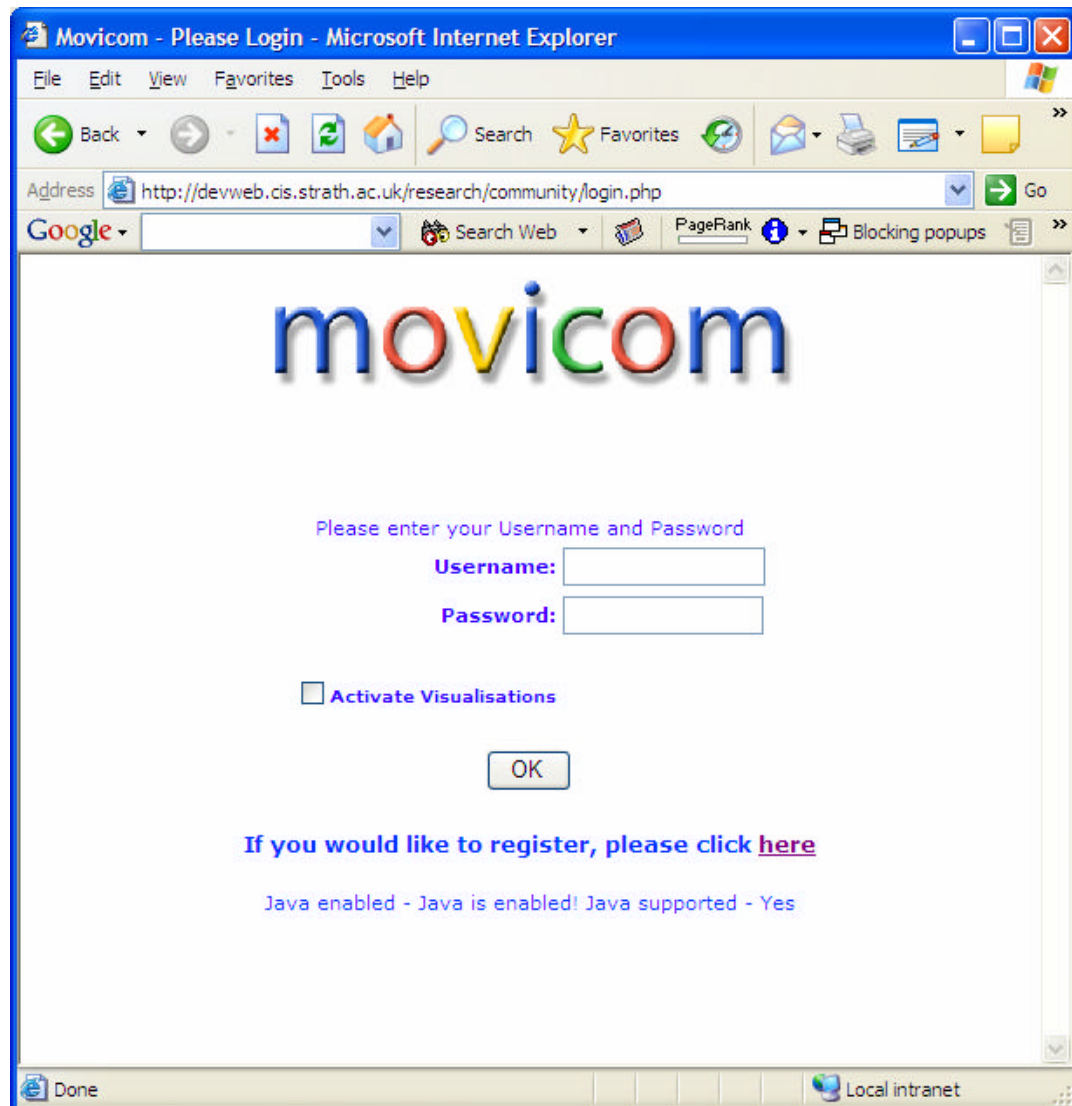
4

5

Other Comments

Please open 'Shortcut 4' from the test folder.

Now log in. Ensure that the checkbox that says '*Activate Visualisations*' is left blank.



BULLETIN BOARD – TASK B1

Examine popular threads with the most posts. Consider *all* popular threads and identify 3 threads which are becoming stagnant with little or no posts made to them recently.

- 1.
- 2.
- 3.

Please answer the following questions, as they relate to the task you have just completed.

1. It was easy to get started on this task	
Disagree	Agree
<input type="checkbox"/>	<input type="checkbox"/>
1	2
<input type="checkbox"/>	<input type="checkbox"/>
3	4
<input type="checkbox"/>	<input type="checkbox"/>
5	
2. It was easy to complete this task	
Agree	Disagree
<input type="checkbox"/>	<input type="checkbox"/>
5	4
<input type="checkbox"/>	<input type="checkbox"/>
3	2
<input type="checkbox"/>	<input type="checkbox"/>
1	
3. I had sufficient time to complete this task	
Disagree	Agree
<input type="checkbox"/>	<input type="checkbox"/>
1	2
<input type="checkbox"/>	<input type="checkbox"/>
3	4
<input type="checkbox"/>	<input type="checkbox"/>
5	
4. I am completely satisfied with my results	
Agree	Disagree
<input type="checkbox"/>	<input type="checkbox"/>
5	4
<input type="checkbox"/>	<input type="checkbox"/>
3	2
<input type="checkbox"/>	<input type="checkbox"/>
1	
5. This task was enjoyable	
Disagree	Agree
<input type="checkbox"/>	<input type="checkbox"/>
1	2
<input type="checkbox"/>	<input type="checkbox"/>
3	4
<input type="checkbox"/>	<input type="checkbox"/>
5	
Other Comments	

BULLETIN BOARD – TASK B2

Examine threads with recent posts. Consider *all* these recently active threads and from these, identify the 3 threads which have been going for the longest period of time.

- 1.
- 2.
- 3.

Please answer the following questions, as they relate to the task you have just completed.

1. It was easy to get started on this task	
<input type="checkbox"/>	<input type="checkbox"/>
Disagree	Agree
<input type="checkbox"/>	<input type="checkbox"/>
1	2
<input type="checkbox"/>	<input type="checkbox"/>
3	4
<input type="checkbox"/>	<input type="checkbox"/>
5	
2. It was easy to complete this task	
<input type="checkbox"/>	<input type="checkbox"/>
Agree	Disagree
<input type="checkbox"/>	<input type="checkbox"/>
5	4
<input type="checkbox"/>	<input type="checkbox"/>
3	2
<input type="checkbox"/>	<input type="checkbox"/>
1	
3. I had sufficient time to complete this task	
<input type="checkbox"/>	<input type="checkbox"/>
Disagree	Agree
<input type="checkbox"/>	<input type="checkbox"/>
1	2
<input type="checkbox"/>	<input type="checkbox"/>
3	4
<input type="checkbox"/>	<input type="checkbox"/>
5	
4. I am completely satisfied with my results	
<input type="checkbox"/>	<input type="checkbox"/>
Agree	Disagree
<input type="checkbox"/>	<input type="checkbox"/>
5	4
<input type="checkbox"/>	<input type="checkbox"/>
3	2
<input type="checkbox"/>	<input type="checkbox"/>
1	
5. This task was enjoyable	
<input type="checkbox"/>	<input type="checkbox"/>
Disagree	Agree
<input type="checkbox"/>	<input type="checkbox"/>
1	2
<input type="checkbox"/>	<input type="checkbox"/>
3	4
<input type="checkbox"/>	<input type="checkbox"/>
5	
Other Comments	

BULLETIN BOARD – TASK B3

Examine the most popular threads. Across *all* these threads, identify the three users who you think have made the most posts throughout the entire history of the bulletin board.

- 1.
- 2.
- 3.

Please answer the following questions, as they relate to the task you have just completed.

1. It was easy to get started on this task	
Disagree	Agree
<input type="checkbox"/>	<input type="checkbox"/>
1	2
<input type="checkbox"/>	<input type="checkbox"/>
3	4
<input type="checkbox"/>	<input type="checkbox"/>
5	
2. It was easy to complete this task	
Agree	Disagree
<input type="checkbox"/>	<input type="checkbox"/>
5	4
<input type="checkbox"/>	<input type="checkbox"/>
3	2
<input type="checkbox"/>	<input type="checkbox"/>
1	
3. I had sufficient time to complete this task	
Disagree	Agree
<input type="checkbox"/>	<input type="checkbox"/>
1	2
<input type="checkbox"/>	<input type="checkbox"/>
3	4
<input type="checkbox"/>	<input type="checkbox"/>
5	
4. I am completely satisfied with my results	
Agree	Disagree
<input type="checkbox"/>	<input type="checkbox"/>
5	4
<input type="checkbox"/>	<input type="checkbox"/>
3	2
<input type="checkbox"/>	<input type="checkbox"/>
1	
5. This task was enjoyable	
Disagree	Agree
<input type="checkbox"/>	<input type="checkbox"/>
1	2
<input type="checkbox"/>	<input type="checkbox"/>
3	4
<input type="checkbox"/>	<input type="checkbox"/>
5	
Other Comments	

BULLETIN BOARD – TASK B4

Examine the most popular threads which have had posts in the last week. From these, identify the three threads with the most posts.

- 1.
- 2.
- 3.

Please answer the following questions, as they relate to the task you have just completed.

1. It was easy to get started on this task
<p>Disagree Agree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>1 2 3 4 5</p>
2. It was easy to complete this task
<p>Agree Disagree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>5 4 3 2 1</p>
3. I had sufficient time to complete this task
<p>Disagree Agree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>1 2 3 4 5</p>
4. I am completely satisfied with my results
<p>Agree Disagree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>5 4 3 2 1</p>
5. This task was enjoyable
<p>Disagree Agree</p> <p><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/></p> <p>1 2 3 4 5</p>
Other Comments

Appendix D Post-System Questionnaires

MATCHING INTEREST - SYSTEM QUESTIONNAIRE

To evaluate the system, you are now asked you to answer some questions.

Take into account that we are interested in knowing your opinion.

Answer questions freely, and consider there are no right or wrong answers.

Please remember that we are evaluating the system you have just used and not you.

Place a TICK in the square that best matches your opinion. Please answer all questions.



1. The matching interest visualisations were:

	1	2	3	4	5	
simple	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	complex
unreliable	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	reliable
interesting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	boring
unattractive	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	attractive
informative	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	uninformative
Relevant	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	irrelevant

2. It was easy to *learn to use* the visualisations

Agree						Disagree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5	4	3	2	1		

3. It was easy to *use* the visualisations

Disagree						Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
1	2	3	4	5		

4. I completely *understand* how to use the visualisations

Agree Disagree

5 4 3 2 1

5. It was easy to assess the usefulness of something from the visualisations

Disagree Agree

1 2 3 4 5

6. I intuitively understood what the visualisations were depicting

Always Never

5 4 3 2 1

7. No further explanation of the individual visualisations is needed before I would feel comfortable using them

Disagree Agree

1 2 3 4 5

8. Across the tasks you carried out, please rate the 3 visualisations?



Poor Excellent

1 2 3 4 5

Poor Excellent

1 2 3 4 5

Poor Excellent

1 2 3 4 5

9. The visualisations gave you information that was:

	1	2	3	4	5	
timely	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	untimely
complex	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	simple
structured	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	incoherent
confusing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	clear
uninformative	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	informative
unobtrusive	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	obtrusive

10. I would trust the visualisations to help find items of interest

Always Never

5 4 3 2 1

11. The visualisations made it easier to complete the tasks

Disagree Agree

1 2 3 4 5

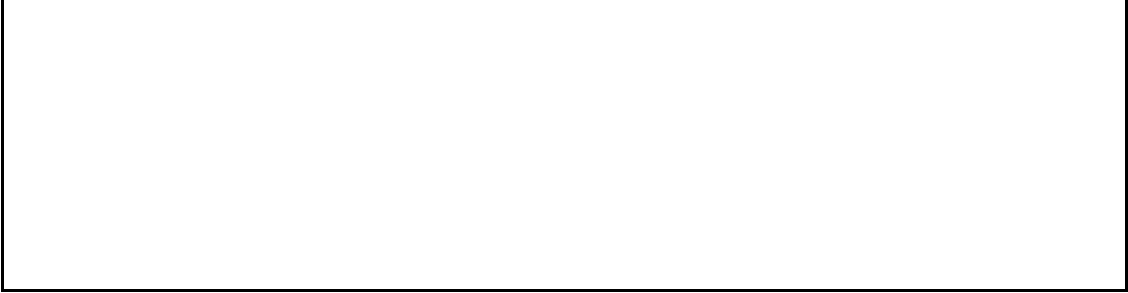
12. I would use the visualisations again

Always Never

5 4 3 2 1

13. Is there any functionality that you would like to see in the visualisations?

14. Do you have any further comments about the matching interest visualisations?



BULLETIN BOARD - SYSTEM QUESTIONNAIRE

To evaluate the system, you are now asked you to answer some questions.

Take into account that we are interested in knowing your opinion.

Answer questions freely, and consider there are no right or wrong answers.

Please remember that we are evaluating the system you have just used and not you.

Place a TICK in the square that best matches your opinion. Please answer all questions.



1. The bulletin board visualisations were:

	1	2	3	4	5	
simple	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	complex
unreliable	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	reliable
interesting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	boring
unattractive	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	attractive
informative	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	uninformative
Relevant	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	irrelevant

2. It was easy to *learn to use* the visualisations

Agree						Disagree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5	4	3	2	1		

3. It was easy to *use* the visualisations

Disagree						Agree
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
1	2	3	4	5		

4. I completely *understand how to use* the visualisations

Agree Disagree

5 4 3 2 1

5. It was easy to assess the usefulness of something from the visualisations

Disagree Agree

1 2 3 4 5

6. I intuitively understood what the visualisations were depicting

Always Never

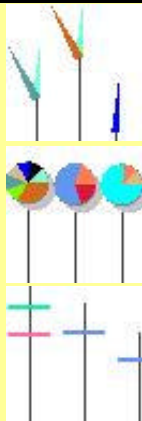
5 4 3 2 1

7. No further explanation of the individual visualisations is needed before I would feel comfortable using them

Disagree Agree

1 2 3 4 5

8. Across the tasks you carried out, please rate the 3 visualisations?



Poor Excellent

1 2 3 4 5

Poor Excellent

1 2 3 4 5

Poor Excellent

1 2 3 4 5

9. The visualisations gave you information that was:

	1	2	3	4	5	
timely	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	untimely
complex	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	simple
structured	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	incoherent
confusing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	clear
uninformative	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	informative
unobtrusive	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	obtrusive

10. I would trust the visualisations to help find items of interest

Always Never

5 4 3 2 1

11. The visualisations made it easier to complete the tasks

Disagree Agree

1 2 3 4 5

12. I would use the visualisations again

Always Never

5 4 3 2 1

13. Is there any functionality that you would like to see in the visualisations?

14. Do you have any further comments about the bulletin board visualisations?

