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Learning Societies Lab

A mini-thesis submitted for transfer from MPhil to EngD

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A Framework for Re-imaging and Enabling Access to Online Social Phenomena

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ABSTRACT

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The digital divide refers to a lack of technological access, part of which involves exclusion from a blooming arena of social interaction. People without mobile phones or PCs cannot access email, SMS or social networking websites; this includes many groups, such as the elderly, who can become vulnerable without good social contact. By enabling multimodal access to a variety of communication channels, including ubiquitous ones such as televisions and home telephones, this set of people can be included in such interactions. However, this social functionality cannot be effectively provided if we do not fully understand the ways in which current web-based social interactions occur.

This report first describes background material related to pervasive and social technologies, ageing, computing in non-work environments, usability, and ethical issues. Next, a prototype pervasive messaging infrastructure for multimodal communications is described, as is its use as an assistive environment. The report also describes the vision for building a social fabric on top of this infrastructure. Two tools to understand social networking experiences, Experience Deconstruction and Actor-Network Theory, are presented. Finally, planned future work is described.

The research question to be addressed is, "Can a systematic framework of methodologies be developed to understand the motivations for and experiences of social web-based phenomena, in order to re-imagine these phenomena in novel contexts?" Planned research contributions are: the analysis and evaluation of methodologies for understanding online social phenomena; the creation and use of a systematic framework to apply these methodologies; and re-imagining the social networking experience via pervasive channels.

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1 Introduction and Motivation

A great variety of communication technologies are in day-to-day use: these include more traditional tools such as email and landline phones, fully established technologies such as mobile phones and instant messaging (IM), and newer items including social networking sites and blogs. These media can be a source of fun (Hart, 2008) and emotional support (Wright, 2002), yet a large chunk of society is excluded from this arena of social interaction. For example, in general elderly people face a range of obstacles to the uptake of technology (Namazi, 2003).

This issue is increasingly important, especially given the trend for ageing populations across the western world, and the geographical dispersion faced by many families. Technologies built without due consideration can exclude users considered 'non-standard', whether due to impairments, economic considerations or cultural aspects. Meeting these considerations when building any system requires a holistic outlook and an inclusive approach to design (Newell, 2004).

Our goal is to connect these offline people through technology with which they are familiar. Opening up fresh communication channels for these people could help improve their general wellbeing. For example, contact with family might become easier (children could email grandparents regardless of whether the grandparents own a PC), and access to online content could be gained without requiring ownership of expensive computers or mobile phones, and knowledge of how to use web browsers. Another use of the system might be to view a weekly printed bulletin of updates about friends and family, and a daily bulletin with important social updates and prompts about the day ahead (appointments or jobs to do). In summary, many more people would be able to access the online content and communications facilities which so many of us take for granted.

The author's focus in connecting these offline people is in enabling access to social networking technologies, as provided by websites such as Facebook, MySpace and Bebo: however, access to broader technologies (such as emails, text and voice messages) is considered.

The vision comprises a social fabric - an interface and social model - supported by a messaging framework. The social fabric enables communication and browsing, facilitated by the messaging infrastructure, which allows interaction via any of a number of communication channels. The combination of these two layers allows the realization of visions such as this:

> *Gerald is an elderly man, who lives alone in a flat. He has no interest in computers, but is happy to benefit from services enabled by technology. For example, he is very interested in seeing photographs from his grandchildren's sports day. A digital photo frame is installed on his wall; when Gerald's son Matt uploads photographs from the sports day to a social networking website, the pictures are displayed in turn on the display.*

Later that day, Gerald's grandson Billy writes him an email about the sports day. Gerald doesn't access his email account on a PC. Instead, the email is translated into an audio file and read to him via his telephone; an alternative way, which Gerald does not prefer, would be a paper copy via a microprinter. Gerald listens to Billy's message late in the day, when Billy is probably asleep. Gerald records a reply, a voice message for Billy to receive in the morning.

Gerald is also particularly interested in a small community of ex-pat friends of his, who live in Spain. He plans to travel to visit them one day, but meanwhile he follows updates about their day-to-day lives online. Gerald accesses these updates via a teletext[1]-style display on his television.

In order to effectively build the social aspects of the system, it is necessary to re-imagine the web-based experiences offered by social sites. Gaining a deep understanding of the experiences offered by social websites is a vital step in achieving this goal.|

This mini thesis discusses these concepts. Section 2 presents relevant background material from the field, covering the areas of pervasive and social technologies, ageing, computing and non-work environments, usability and HCI, and ethical and moral aspects; it closes with a discussion of the intersection of these areas. Section 3 describes the approach taken to exploring social networking, presents items being analysed and a deconstruction of these, and discusses these matters. Section 4 discusses the multimodal messaging infrastructure which might support a social fabric: this section provides some background material, a model description, and a discussion, analysis and evaluation of the prototype system. Section 5 presents future work and conclusions, including research questions and an ongoing plan of work. Finally, section 6 provides references.

[1] Teletext is a text-based television information retrieval service, which runs in the UK.

2 Background

This section outlines six research areas relevant to this research.

2.1 Pervasive Technologies

The term 'pervasive computing' appears to have connotations with actual computing systems (e.g. Varshney (Varshney, 2003), Lorincz (Lorincz, 2004) and Stanford (Stanford, 2002)), while 'ubiquitous computing' seems to have been associated with Weiser's vision of 'calm computing' (Weiser, 1989) (Brown, 1999). That said, the current literature (and therefore this document) largely uses the terms 'pervasive' and 'ubiquitous' interchangeably. For example, Ark and Selker (Ark, 1999), in their introduction to the 1999 IBM Systems Journal, explicitly state "The terms *pervasive computing* and *ubiquitous computing* are used interchangeably throughout this issue." Similarly, Korhonen and Bardram (Korhonen, 2004), in their introduction to the section on pervasive healthcare in the IEEE Transactions on Information Technology in Biomedicine, refer to "pervasive computing—or ubiquitous computing, proactive computing, ambient intelligence."

Pervasive or ubiquitous computing involves the availability of many effectively invisible computers throughout the physical environment (Weiser, 1989): that is, the technologies are so transparent to use that people do not notice them. Weiser suggests this invisibility as analogous to text: people do not explicitly notice or struggle with text in newspapers, books, adverts and on food wrappings, but simply read it if they so desire. Weiser describes pervasive technologies as being the opposite of Virtual Reality technologies, which work to simulate an alternative world: in comparison, pervasive technologies invisibly enhance the existing environment.

Weiser (Weiser, 1993) suggests traditional computers are in the way of work to be done, not due to their interfaces, but because they demand the focus of those using them. Weiser suggests that pervasive systems can be used by those in shared situations, regardless of their technological skills: people can simply pick up a notebook-sized computer, which is not associated with one specific person but is analogous to (and as easy to use as) scrap paper, and use it, whether in a shared context or not.

The aim of this is to produce 'calm' computing, where the technology is not the focus of people's attention, and where the people using it control the technology, rather than being driven by it (Brown, 1999).

There are, of course, ethical issues associated with this kind of wirelessly-networked, ubiquitous technology (Stone, 2003), not least surrounding privacy. These are discussed in Section 2.6.

Some researchers have investigated methods to support small screens. For example, Brewster (Brewster, 2002) suggests the use of sonically-enhanced buttons to augment the information provided visually,

increasing their usability and allowing their size to be reduced. Tests in the usability laboratory found that this worked very well, although testing in more realistic situations (whilst walking outside) found the improvements were not quite so strong. Nonetheless, the addition of sound decreased the workload for users, and participants found it less annoying than having no sound. The effect on bystanders was not investigated.

Ark and Selker (Ark, 1999) in their introduction to an IBM Systems Journal focused on pervasive computing, note that there are a hugely broad range of areas for pervasive computing research. These include, but are not limited to education, communications, infrastructures, input devices and social uses.

2.2 Understanding Social Technologies

Various academic works consider social aspects of technology: for example, Foth (Foth, 2006) discusses how internet technologies can impact social formations of urban residents, while Ridings and Gefen (Ridings, 2004) explore why people join virtual communities.

Some work focuses on elderly users. Donaldson (Donaldson, 2005) describes two devices to facilitate companionship and discussion between co-located elderly people: these are the 'TeleTable', used to arrange and organise digital media, and the 'Pitara', used to associated physical mementos with digital media. Keyani (Keyani, 2005) presents a dancing environment to provide elders with exercise, entertainment and social engagement.

Other technologies focus on linking families. Mynatt (Mynatt, 2001) present the 'digital family portrait', a device to convey an impression of a family member's daily life over the last month: this accounts for health, relationships, activity and events. Plaisant et al (Plaisant, 2006) present shared family calendars, a method for multiple generations of a family to share their calendar information as a tool to increase connectedness.

Similarly, Sellen et al (Sellen, 2006) describe the whereabouts clock, a device to support awareness of people's location and activities in an office environment. Initial evaluation suggested that it helped people have a virtual presence, locate others, and feel they belonged in a group of colleagues.

2.2.1 Social Networking Websites

This report focuses on social networking websites. There are varying definitions of these sites: boyd and Ellison (boyd, 2007) define them as sites which allow users to construct a public or semi-public profile; articulate a list of users with whom they share a connection; and view and traverse these lists. Meanwhile, Golbeck et al (Golbeck) suggest that dating sites such as Match.com are not social networking websites, while other sources (Abram, 2008) suggest they are. boyd and Ellison (boyd, 2007) also note that social sites are often about expressing existing connections, rather than meeting

strangers, and are primarily organised around people rather than interests: this is a contrast to Usenet and forums, which are traditionally organised around topics.

Social websites may have different focuses, for example towards blogging, careers, religion or general social interactions. For the purposes of this work, 'social networking websites' are sites which offer a specific focus upon augmenting relationships.

User experience of these websites appears to vary wildly, according to the specifics of the site and the way in which it is used. Types of use include searching for new friends, maintaining existing relationships and investigating people met offline (Hart, 2008). Sas et al (Sas, 2009) discuss the emotional experience of using the Facebook site. They suggest that the main uses of Facebook are cooperative, and that the most memorable experiences are private communications between close friends and engagement in public performance while experiencing entertainment.

It would appear that existing, widely-accepted usability guidelines (such as Nielson's ten guidelines (Nielson, 1994)) are not applicable in this new area. According to those guidelines, Facebook is terribly designed (for example, its design is not "aesthetic and minimalist"), and yet its success suggests that it is certainly not hard to use (Hart, 2008). Understanding the modern day web experience may help drive more holistic design guidelines.

Reaching this understanding may not be simple. Experiences which superficially appear similar may manifest differently in different media. This is demonstrated by Dix's use of deconstruction to translate the experience of pulling Christmas crackers from a physical to a digital domain (Dix, 2003). Deconstruction offers a method for understanding user experience, and is explored further in Section 3.4.

An alternative method for understanding experience involves Actor-Network Theory (ANT). This emerged from the work of Callon (Callon, 1986) and Latour (Latour, 1987), and models the flow of interactions and processes between actors; it is explored further in Section 3.7.

2.2.2 The History of Social Networking Sites

boyd and Ellison suggest that the first social network site was SixDegrees.com, which launched in 1997: the site allowed users to build profiles, list friends and (from 1998) browse friends lists. These items of functionality were available on different sites before 1998, but not in combination. SixDegrees closed in 2000, while from 1997 to 2001, various community tools become social sites by adding support for profiles and publicly listed friends. Figure 1, below, shows boyd and Ellison's history of launch dates for many major social sites, according to their definition of such sites (see Section 2.2.1).

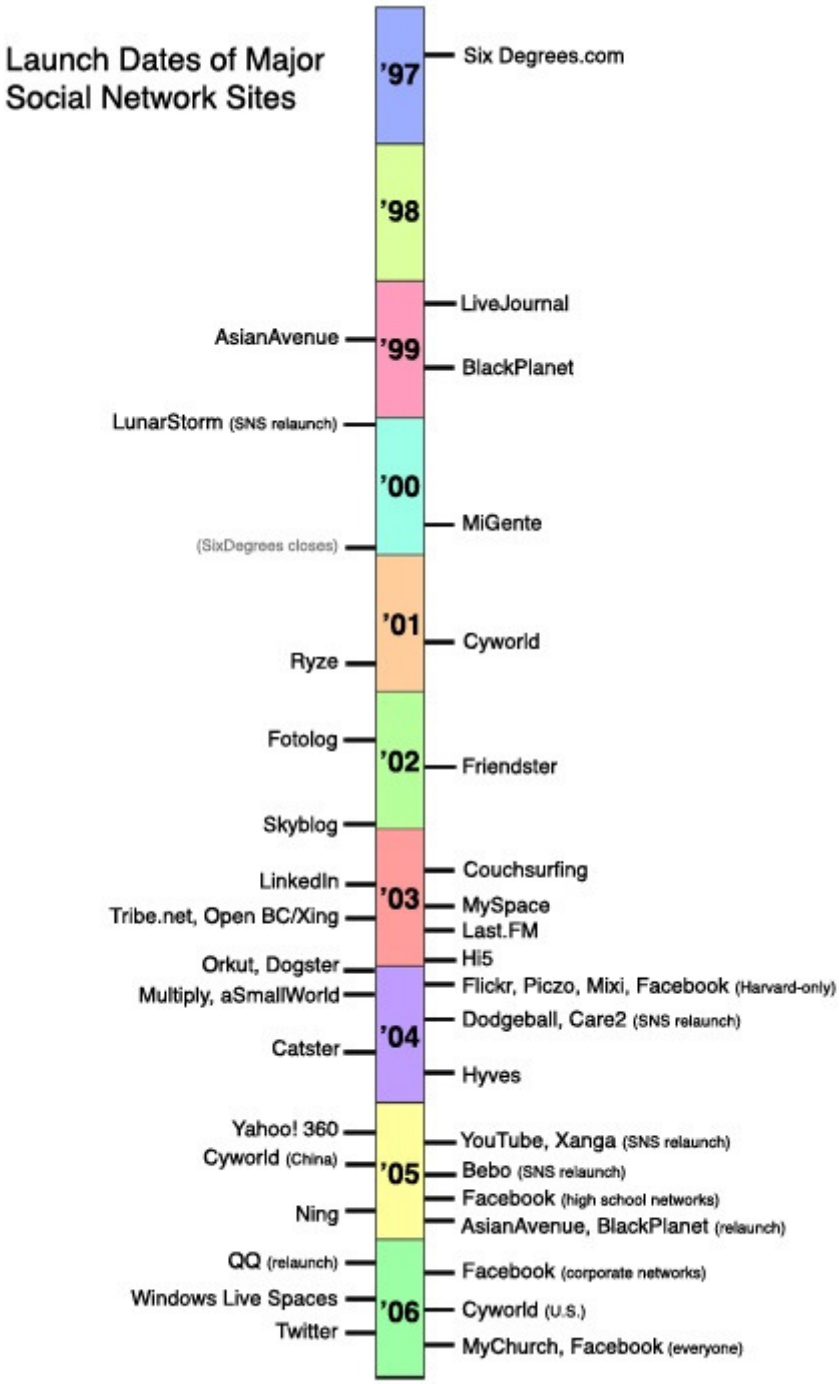


Figure 1: Timeline of launch dates of major social sites and dates when community sites re-launched with social features

Since 2006, the profile of social networking sites has continued to increase. Twitter, a lightweight microblogging platform, launched in March 2006. By January 2009, the BBC reported (based on material from industry analysts HitWise) that UK usage of Twitter had rocketed by almost 1000% over the past year. Meanwhile, a list of major, active social sites on wikipedia included 197 items, as of April

2009: this non-exhaustive listing excluded niche social sites, such as those made possible by services such as Ning, a website which enables users to build their own social sites.

It is difficult to discern the dates at which specific items of functionality (e.g. photo sharing, or public and private messaging) appeared. However, it is possible to consider the origins of social networking sites, which did not all begin as such. For example, QQ began as a Chinese instant messaging service, LunarStorm as a community site, and Skyrock as a French blogging service: each of these later added social networking features (boyd, 2007). Similarly, various ethnic community sites (AsianAvenue, MiGente and BlackPlanet) re-launched in 2005-6 with social networking features and structure.

As can be seen in Figure 1, many new social sites launched from 2003. Most of these were profile-centric, but professional sites such as LinkedIn also appeared, as did interest-specific sites such as Dogster and MyChurch. Finally, as social media and user-generated content bloomed, media sharing websites added social features - these include Flickr, Last.FM and YouTube.

2.3 Ageing

The UK population in 2004 was 59.9 million, with a median age of 38.6 years (Society, 2006). It has been broadly predicted that the population will reach 65 million by 2021, with a median age of around 41 or 42 years. The proportion of the population aged over 65 years is expected to have risen from 16% to around 18%. Although elderly people are by no means the only group with generally poorer access to technologies, they are certainly a significant one (Namazi, 2003). Given this significance, it is important to consider the effects of ageing, and the relevance of these effects to this research.

2.3.1 Changes Associated with Ageing

A widely acknowledged psychological change that comes with age is the decline in cognitive processes, especially memory (Mather, 2005). However, not all types of cognitive process decline with age: for example semantic memory (memory of meanings and understandings) typically increases or remains steady. As such, recall of words studied a few minutes previously has been shown to decline over a four-year period, but implicit memory of recently studied words does not show a decline with age.

Shock (Shock, 1951) carried out a great deal of work looking at ageing. He notes that hearing, vision and motor responses are all affected by ageing: loss of hearing is greater in males, and the loss tends to affect the higher tones more. Presbyopia (farsightedness) tends to occur with ageing, and the elderly require a greater minimum level of light. Motor responses are slower, due to changes at various levels of the nervous system; a very gradual decline begins between 40 and 50 years of age. That said, there is a large range within this: the performance of the fastest third of the eldest group in a study equalled the average performance of the young group. Reaction times also slow, with a positive correlation between

the length of reaction time and age of participant, which was significant even between the ages of 17 and 36.

Shock also noted that average scores on intelligence tests diminish with increasing age: vocabulary type scores are good, but those involving numerical computation, series completion, picture arrangement and so forth all featured a significant decline. The most difficult areas were those where subjects had to break away from old mental habits and adapt to unfamiliar situations. Shock notes, however, that the elderly have slower responses and more knowledge and experience, all of which biases the results of such tests.

Shock also notes that there are wide differences in the decrement of performance with age. The relationship between performance level and age decrement is greatest in those with lower performance ability; in the upper 5% of the population he found the decrement to be minimal or absent.

Jacko examined the effects of multimodal feedback on the performance of older adults with different visual abilities (Jacko, 2003). Results suggests that non-visual (auditory or haptic), multimodal feedback resulted in performance gains over visual feedback, for users with normal and users with impaired sight.

The elderly cannot be simply classified as one group: they are hugely diverse, particularly given the extensive and varied life histories and experiences which define them. Nonetheless, certain physiological changes, described above, tend to be found in us all as we age. These must be considered when designing computer systems for the elderly.

2.3.2 Uptake of Technology by the Elderly

An issue in this arena is the uptake of technologies by the elderly. Namazi et al (Namazi, 2003) noted a range of obstacles to this uptake, which vary widely. Obstacles may be physical and cognitive, personal, technological, organisational or environmental. It is important to ensure that the elderly are not pressured to take on new systems in which they have no interest.

Pfeil (Pfeil, 2007) notes the increasing use of virtual communities online and the importance of making these technologies accessible to people, such as the elderly, who have different needs. Wiley (Wiley, 2006) present the design of a simple, pen-and-paper based interface to allow elders access to email. Hirsch (Hirsch, 2000) describes a four-month study into the experience of elders and caregivers, and concludes that social, emotional and environmental factors all play a key role in the eldercare experience and the adoption and use of new products: this is another argument for a holistic approach to design.

There exist several theories used in Information Systems research that could be relevant. The first is the Technology Acceptance Model (Davis, 1989), in which perceived usefulness and ease of use determine an individual's intention to use a system. The second is the Unified Theory of Acceptance and Use of Technology (Venkatesh, 2003), in which usage intention and behaviour is influenced by user

expectations of performance and effort, as well as social influence and facilitating conditions. This model is the unification of eight prior models, including the Technology Acceptance Model. Such models may be useful during the course of this research, especially as the technology in question is not being used in standard, workplace environments.

2.4 Computing and Non-work Environments

It has been noted that both domestic and care environments are very different settings to the workplace (Cheverst, 2003). Care must be taken when working in these new areas to avoid blindly following the assumptions and methodologies associated with workplace-based research: for example, examining personal routines and environments can be seen as inappropriate and intrusive. That said, in some respects carrying out research can be easier in these environments. For example, buy-in is generally gained from all participants, not just the owners of a particular facility, who require their employees to cooperate.

Some aspects of domestic and care environments are emotional. Work environments are generally regarded as just that: professional places where work gets done. However, these other environments have very different uses, some of which are 'worklike' (the administration of balancing household accounts, for example, and paying bills and cleaning), others of which are completely different (such as family meals, parties, television watching, game playing, and so on). In these environments, the primary aim is living, not productivity (Cheverst, 2001).

One piece of research looking at living and not productivity is by Howard et al (Howard), who investigated the support of intimacy between family members. They note the ambiguity of intimate communications, which convey emotions and feelings, and are very private. Electronic 'gifting' is described: this is the giving and receiving of messages of love and appreciation.

Technologies in domestic environments need not be staid or predictable: they can be used in creative and ludic ways. For example, Gaver et al (Gaver 2004) present the Drift Table, an electronic coffee table which displays slowly moving aerial photography. The movement of this photography is controlled by the distribution of weight on the table's surface. Gaver et al used the table to investigate ludic activities: activities motivated by curiosity, exploration and reflection.

Another project of Gaver's was the History Tablecloth (Gaver, 2006): this was a flexible screen printed with electroluminescent material to form a grid of lace-like elements. When objects were left on the table, cells beneath them lit to form a halo that grew over time, showing the flow of objects.

Paulos (Paulos, 2003) discusses the importance of play, illustrating its relevance to pervasive tasks such as blogging, tagging and message play. As can be seen, re-imagined functionality need not be limited to standard use of standard technologies.

‘Smart home’ projects may also be considered. One such project is the Aware Home (Kidd, 1999), which consisted of two identical living spaces. Aims included investigation of context awareness and ubiquitous sensing, and individual interactions with the house. Another project is the Millennium Home (Dowdall, 2001), aimed at elderly users who are not cognitively or physically impaired, but are at risk of becoming ill or injured through the course of home life.

Perry et al (Perry, 2004) note that only 10% of older people live in supported accommodation and that characteristics of the elderly population tend to include forgetfulness, a fear of crime, and hearing and motor limitations. Consistency is important in systems for this user group, as different interaction methods can be confusing. User preferences are likely to be broad, due to differing backgrounds.

Other work has considered technical, social and pragmatic challenges involved in providing such technologies in the domestic environment (Edwards, 2001). Edwards and Grinter list seven such challenges, including issues such as setting up and maintaining technologies, and reliability.

Technology is often intertwined with routines – for example, Crabtree and Rodden (Rodden, 2004) often encountered situations where a household member would watch a specific program on the television (or listen on the radio) before leaving for work, or carrying out some other daily activity.

A similar piece of work by Hughes et al (Hughes, 1998) considers design challenges of domestic environments. It was noted that the placement of technology within the home reflected the daily routines of inhabitants. Spaces are designed to support particular activities, usually multiple activities: a room may perform as a study, playroom, guest room or games room, depending on its configuration.

Rodden and Benford (Rodden, 2003) have considered the form of buildings, and the implications of this for pervasive technologies. They note that one can understand the domestic setting through ethnographic studies, longitudinal studies and design based methods.

Newell and Gregor (Newell, 2004) discuss specialist and mainstream design for older and disabled people. They note some differences found in older users: elderly users are more likely to have one or more disabilities, as well as different wants and needs to able-bodied users. Those with disabilities are only a fraction of the population of people with reduced functionality: everyone can be temporarily disabled by accidents, alcohol, stress, fatigue or their environment.

There is a difference between traditional user-centred design for able-bodied users, and that for user groups including those with disabilities. Newell and Gregor have proposed ‘user-sensitive inclusive design’, where older and disabled users are included as informants on research and development teams. They also note the value of narrative methods such as story-telling metaphors, and attention to the aesthetics of design.

Understanding user requirements in care settings (such as care homes and hospices) can pose methodological challenges (Cheverst, 2003). It is necessary that designers know not only what they are

designing and what it should do, but also who will use it. Designing for people just like the designers themselves may exclude a host of people, including the disabled and those in care.

Cheverst et al (Cheverst, 2003) carried out research in a hostel for former psychiatric patients. They used several techniques, including ethnographic study, user-centred design and evaluation, and cultural probes (Gaver, 1999). These methods helped Cheverst et al to build two systems: one provided medication reminders, and the second allowed patients to send an alert when in danger or distress (Cheverst, 2001).

Dewsbury (Dewsbury, 2001) has considered the social and psychological aspects of smart home technology specifically within the care sector, noting that assistive technology does not replace personal care. Recommendations include taking a long-term view of the inhabitant's condition, considering emotional aspects, and considering all stakeholders.

2.5 Usability and Human-Computer Interaction

The suitability of a computer system's interface is always important: even the most useful and efficient system is worthless if people cannot use it correctly. Having an appropriate interface becomes still more important when dealing with a pervasive system, due to the novel nature of that interface: for example, is there a standard, textbook interface for a medical temperature-monitoring system? It has been noted that interaction with smart homes can be difficult (Dowdall, 2001). Similarly, the appropriateness of a system's interface is particularly important when the people who will use it are not able-bodied – for example, the elderly, small children, or those with health problems (Newell, 2004).

Gould and Lewis (Gould, 1985) describe three principles of system design which allow production of a useful and easy to use computer system. These are:

1) early and continual focus on users.
2) empirical measurement of usage.
3) iterative design whereby the system (simulated, prototype, and real) is modified, tested, modified again, tested again, etc.

Although these principles are straightforward, Gould and Lewis' evidence suggests that they are not always intuitive to designers: 447 designers were asked to list five major steps in developing and evaluating a new system. Only 16% mentioned all three items, and 26% mentioned none.

Awareness of the end-users of a system is essential. Cultural probes are one method for building this awareness. These were designed by Gaver et al (Gaver, 1999): they are packages sent out to research participants containing maps, postcards, cameras and booklets. Postcards would have very open-ended questions, such as 'what is your favourite device?' or 'what place does art have in your life?' Cameras

had similarly open requests for photographs. The packs were designed to be informal and friendly, and to elicit the participants' attitudes to life, cultural environments and technology.

The researchers found that the probes reduced the distance caused by their professional status (as well-funded experts), as well as reducing geographic, cultural and linguistic distances. They gained invaluable knowledge about the elders of the communities to whom they sent the packs, comparable in volume to that gained from other methods.

Hughes et al (Hughes, 2000) consider design patterns as a means of presenting ethnographic materials and sharing knowledge about application domains and design solutions. They suggest a template, which describes, amongst other aspects, the motivation for the pattern and problems solved; context; examples; and positive and negative consequences of the pattern's use.

User studies can help increase the understanding of how people interact with systems. Interviews can elicit user experiences of current technologies, while user trials help with system evaluations. Shen (Shen, 2007) describes intrusive and non-intrusive methods for evaluating information systems, and measuring the impact of ambient information systems in particular, while Kazmer (Kazmer, 2008) evaluates different strategies for collecting qualitative semi-structured interview data about Internet-based research topics.

2.6 Ethical and Moral Aspects

It is important to be aware of the ethical implications of any research. These aspects are particularly relevant when dealing with elderly or vulnerable users, using technology of a potentially invisible nature, and accessing highly sensitive information relating to health or security around the home.

The ethical implications of pervasive technologies attract attention, due to fears over issues such as the data theft. Stone (Stone, 2003) discusses some issues. One example used is the EZ Pass, which tracks cars and allows the users to automatically pay highway tolls, speeding up traffic: yet use of such a pass allows the tracking of cars as they pass through toll gates. Wearable tracking devices for children are discussed: if a child is kidnapped or lost, these devices would be extremely useful. As Stone points out, however, it is unlikely that a teenager about to go out on a date would hold such a viewpoint. Others are yet more concerned at these technologies, with a Professor of applied ethics saying "We are building an infrastructure for totalitarian control."

Another Professor suggests a future where people embed devices which could, for example, increase their elasticity, letting them jump higher: he says this will threaten our sense of what it means to be human. He does not discuss existing augmentations, such as glasses, pacemakers and false teeth.

A major issue when providing assistance via technology is correctly empowering users and supporting independent living, rather than simply creating a dependence on the technology (Cheverst, 2001)

(Cheverst, 2003). Awareness of the individual care needs and social implications of the technology is deeply important, as is awareness that technology cannot simply perform tasks for people without potentially creating dependence.

Ting (Ting, 1999) notes that the issue of confidentiality is growing in prominence as use of computing and communication technologies spread. (These concerns are not new; Weiser (Weiser, 1989) noted nearly two decades ago that one rogue device could record everything in a room.) Various legislation, such as privacy and freedom of information acts, has been introduced, although it has been said that US legal safeguards on privacy are inadequate, fragmented and inconsistent (Gostin, 1997).

Introna and Pouloudi (Introna, 1999) note the need to disclose information for the benefit of some people, and to safeguard the privacy of other people by not doing so. They describe this tension as being between privacy and transparency. They note that privacy is hard to define, with no universally accepted definition existing. Definitions range from 'the right to be left alone' (Brandeis, 1890) to 'control over knowledge about oneself' (Fried, 1968).

Another important aspect is intrusiveness, which is a noted issue (Ramchurn, 2004): providing the right information on the right device at the right time and with the right level of intrusiveness has been discussed previously (de Roure, 2005).

2.7 Challenges in the Intersection of these Areas

In summary, pervasive technologies involve the availability of many ‘invisible’ devices distributed through the environment. Issues include privacy and security, and the novel nature of these technologies mean that usability issues are especially important.

Socially-oriented work considers virtual communities, devices to facilitate face-to-face social interactions and devices to increase presence for geographically disparate work or family groups. Social websites support a rich array of online interactions, and various techniques may help in understanding their use. When considering computing and non-work environments, the different needs and desires of elderly or disabled users should be considered, and playfulness can be an important aspect of systems. Designs must account for all users, not just an able-bodied majority. Similarly, the vulnerability of older users should be considered, along with their different (and very broad) profiles.

The literature suggests the importance of suitable interfaces, user-focused design and a holistic approach which accounts for non-technological aspects such as the comfort and social interaction of users.

The technologies described in this section are distributed through various environments: the family home, flats, warden-controlled flats, care homes, hospitals, and the world at large. Little technology appears to exist for use outside residential environments, or to facilitate communication via novel interfaces.

There exist various issues when considering these areas:

Resistance to change and wariness of technology

The elderly are generally more resistant to change than younger members of society, and are thus more cautious about adopting new technologies (Gill, 1985). The elderly can be intimidated by computer systems (Namazi, 2003): Namazi et al note that computers are not designed for operation by frail individuals and elderly persons with physical or mild cognitive impairments. As such, will elderly people want to use new technologies? How tolerant will they be of problems in such systems?

Use of existing technologies which with the elderly are familiar (for example, televisions and phones) can provide a possible way forwards. It is important that systems are unintimidating, with a minimal learning curve: Weiser (Weiser, 1989) wrote about being able to pick up a computer and use it, as you would a piece of paper. Use of technology acceptance models such as those described in Section 2.3.2 could help predict the outcomes when new users are presented with technologies.

Emotional impact and perceptions

It is important to consider the emotional impact of any technologies introduced. Technologies which superficially increase the social connectedness of an elderly home-owner, for example, may in fact increase their isolation: relatives who have assumed responsibility for checking they are well may feel a reduced need to 'check in' with them. It is important to examine people's perceptions of the systems with which they interact.

Studies outside the workplace

There seem to be few studies looking into people's interactions and use of technology outside the workplace. In general, they appear to be avoided, and seen as inappropriate and intrusive, despite Cheverst et al's (Cheverst, 2003) successful use of ethnographic study, user-centred design and cultural probes to elicit useful information in these environments. It would appear that such studies need not be inappropriate or intrusive: indeed, in some respects they can be easier than workplace-based studies. For example, as a rule the entire household agrees to take part, in contrast to a workplace study where individual employees may not be consulted beforehand.

Intrusiveness

The question of intrusiveness is highly relevant: for example, monitoring someone's location raises many issues. Would people agree to this monitoring? How would it affect their daily lives? Who would be able to access the data?

3 Social Fabric

As described in Section 1, the author is considering approaches to building a social fabric. This fabric would comprise an interface and social model, and use a messaging infrastructure to convey social materials. A first step towards building this fabric is to deeply understand online social experiences: this section describes and demonstrates the use of Experience Deconstruction and Actor-Network Theory to this end (Owens, 2009a).

3.1 Experience Deconstruction, as Presented by Dix

Deconstruction is a design tool for understanding user experience, useful for providing equivalents to existing experiences in new contexts. The method is holistic and creative, rather than a traditional engineering approach, and it is best used as a tool to prompt directed generation of ideas. Alan Dix (Dix, 2003) first used the process with Christmas crackers.

A cracker is made up of an inner tube wrapped in brightly coloured paper. When pulled by two people, it splits into two uneven parts, making a bang as it does so (caused by a small chemical mechanism called a cracker snap). Crackers generally contain a paper hat, a small plastic toy and a motto or joke.

Dix wanted to create virtual crackers on a website. Rather than trying to emulate real crackers, Dix succeeded in capturing aspects of the experience of pulling crackers, and translating those to the medium of the web. He did this by deconstructing the experience of pulling a cracker, and then reconstructing it in the new medium. By deconstruction, Dix refers to "taking apart, teasing out the strands that make something what it is … and, in this context, especially those that make something 'work' as an experience or as a designed artefact."

Deconstruction involves consideration of surface elements and experienced effects. An example surface element of Christmas crackers is that they are traditionally 'cheap and cheerful': thus the webpage for virtual crackers was simple, with cheerful graphics. An aspect of the experience of pulling a Christmas cracker is the shared nature of the experience. To incorporate this, the virtual cracker system would not allow the sender to see the contents of the cracker until the recipient had 'pulled' it (by clicking on a link).

3.2 Analysing the Design Tool of Deconstruction

The process of deconstruction as presented by Dix appears to break into four basic steps:

1) Describe the chosen functionality and the experience of using it.
2) List surface elements of the experience, such as the nature of the design (e.g. 'simple') and the physical parts of the design (e.g. 'diagonal line').

3) List experienced effects of the experience, such as ‘sharing’, ‘openness’ or ‘excitement’.
4) Consider how to translate the surface elements and experienced effects to the new modality.

The lists generated in steps (2) and (3) describe the experience in an abstracted manner, away from the constraints of the original modality.

However, the above breakdown is merely extrapolated from the example deconstructions given by Dix, who does not himself describe the process in detail. There appear to be some inconsistencies in Dix’s implementation of deconstruction: surface elements used in his paper include very literal items (e.g. ‘strong box’, ‘single thick diagonal line’) and items which seem more experiential, such as ‘play’ and ‘dressing up’. Experienced effects do seem to be consistently experiential, including items such as ‘breaking boundaries’, ‘co-experience’ and ‘excitement’.

On balance, it appears that Dix considers artifacts and properties to be surface elements, which are largely nouns and adjectives, while experienced effects tend to focus upon the physical, emotional and intellectual effect upon participants: these descriptors tend to be abstract nouns, noun/verb pairs and perhaps adverbs.

Experienced effects can be broken into two further subtypes, literal and abstract effects. Literal effects are concrete in nature, such as a loud noise or broadcast of information. Abstract effects are not concrete, and tend to concern emotional and intellectual effects. Examples are surprise, connectedness and cultural connotations. Note that literal effects can lead to abstract effects, but also that either subtype of effect may exist without having a corresponding other half.

Based on the above, the deconstruction approach can be described more accurately:

1) Briefly (in no more than 200 words) describe the chosen functionality and the experience of using it[2].
2) List surface elements of the experience. These are generally nouns and adjectives relating to the design, such as ‘bold diagonal line’, ‘simple text box’ or ‘complex arrangement of photos’.
3) List experienced effects of the experience. These focus on the physical, emotional and intellectual effect upon participants, and tend to be abstract nouns, noun/verb pairs and perhaps adverbs. They are literal (e.g. ‘a loud noise’, ‘broadcasting information’) or abstract (‘excitement’, ‘co-experience’) in nature.
4) Consider how to translate the surface elements and experienced effects to the new modality.

[2] This step limits the description to 200 words, or just under half a page of text. This is because deconstruction involves focusing in on one specific experience: if the experience cannot be succinctly described in 200 words, the participants are probably trying to deconstruct something too broad. The solution is to break the experience in question into several parts.

Step four involves reconstructing the experience. It is worth considering whether a logical, step-by-step methodology can support this step: two possible approaches exist. The first approach is transformative:

1) Takes one of the abstract elements or effects (for example, 'openness')[3]
2) Choose an experience in the end domain which matches this effect (for example, 'chatting in a café')
3) Consider whether the chosen experience matches the next element or effect (for example, 'one-to-many communication').
4) If it does match, move to the next element or effect; if not, adjust the experience in the end domain to allow for this ('shouting in a café').
5) Repeat these steps until the reconstructed experience satisfies all of the surface elements and experienced effects of the original experience.

This first approach is demonstrated in Section 3.4.3, where the location of audio equipment is adjusted to reflect the positioning of public messaging functionality in the Twitter webpages.

The second approach involves a functional matching of the abstract elements and effects with the new, reconstructed experience. Instead of taking the incremental adjustments of the transformative approach, the designer attempts to match the entire list of elements and effects with the capabilities available in the domain of the desired, reconstructed experience. This is demonstrated in Section 3.4.1, which gives a reconstruction of Facebook-style public messaging.

3.3 Approach to Deconstructing Online Social Networking

Dix's approach to Christmas crackers involved deconstructing a real-world experience and reconstructing it in a digital context, the web. By contrast, the author wishes to deconstruct a digital experience (using social sites for communication and awareness of friends' activities) and reconstruct it in a different digital context, providing that information and interaction via novel pervasive channels.

Deconstructing the overall experience of using social networking websites, which offer a plethora of communication and awareness tools, is a problematic task. This is because use of each of these appears to produce an experience perhaps greater than the sum of its parts. Deconstructing the browsing of a social website is almost equivalent to deconstructing the browsing of the web: both items are comprised of many nodes and connections, points of functionality and diversion, and huge quantities of data. Given this, the author chose to pick out several key aspects of functionality common to social websites and deconstruct their use.

[3] Note that if a concrete experienced effect is chosen, it may be necessary to consider a corresponding abstract effect. For example, 'a loud noise' is irrelevant if re-imagining Christmas crackers for a Deaf community: however, the corresponding abstract effect of 'surprise' can still be facilitated via other means. This illustrates the importance of context in reconstruction: it is necessary to understand the effects of 'a loud noise' when pulling Christmas crackers.

The first step towards this process was to survey the functionality offered by a range of social networking sites, and analyse which functionality is key across this range. Abram and Pearlman (Abram, 2008) explain what Facebook is. In the course of this explanation they list other social websites: MySpace, Friendster, Orkut, LinkedIn, Windows Live Spaces, Bebo, Meebo, Match, and QQ. These sites have various differences: for example, MySpace focuses on music, LinkedIn is designed for career-related networking, and Match is a dating tool.

The author examined the homepage of each site. Each offers an array of features and functionality: it appears that items linked prominently on the home page (links visible without scrolling down) are primary features, and other functionality is peripheral. Examples of peripheral functionality are 'to do' lists on Bebo, birthday listings on Facebook, and classified adverts on MySpace. (Note: Meebo simply provides Instant Messaging functionality, while QQ is in Chinese, and thus beyond the reach of the author: as such, neither of these sites is further examined.)

It was necessary to normalise the language used by these websites, so as to product a common terminology: for example, many sites include upon profile pages a 'scrapbook', 'wall' or 'whiteboard'. This is a space for friends (and the profile-holder) to leave notes. This document refers to this as 'public messaging'.

Functionality common across the sites was: a profile, including a microblog; a friends list; public and private messages; photos; applications; groups (or 'forums' or 'communities'); and news feeds. There were some exceptions: LinkedIn, Match and Twitter do not supply all of this functionality. This is presumably because the functionality is not always relevant to LinkedIn and Match (photographs are rarely relevant in careers-related discussion, and Match users probably don't want messages to be public), while Twitter has always aimed at being a lightweight social service.

Appendix A: Functionality Provided by Social Sites fully lists the primary functionality of each site.

Common items in profiles are: name, picture, age, gender, relationship status, location, free text (e.g. to list interests or quotes), contact information (e.g. email address, IM username, URL), listings of schools/workplaces, and a current 'status' (a microblog). Again, there are exceptions, notably LinkedIn (which does not include personal data such as age and gender) and Twitter, which provides a very lightweight profile.

Appendix B: Profile Data Provided by Social Sites lists the profile fields for each site.

Having elicited the key functionality of social websites, the next step is to examine the surface elements and experienced effects of this functionality, in order to abstract it for transfer to new media. The methodology for this process is described in Section 3.2.

3.4 Deconstruction in Action

This section presents deconstructions of various types of social functionality across three social sites: functionality which is deconstructed is microblogging, public messaging, photo sharing and groups. The first two items are similar in some respects, as both involve sharing a small quantity of text in a fairly public way. It is hoped that deconstruction shows the differences between these. Photo sharing and groups were chosen as they provides a contrast to the other two items.

The three social sites used are Facebook, Orkut and Twitter. Facebook and Orkut offer fairly similar social functionality, and it is hoped that deconstruction helps show differences between the sites: by contrast, Twitter stands out as a lightweight social networking mechanism, and may provide a contrast. Note that Twitter does not provide photo sharing, and so there is no deconstruction of this functionality.

Each deconstruction is followed by a brief outline of the properties one might observe in a reconstructed instance of the experience, and an example reconstruction.

Table 1, below, shows the section number of each deconstruction.

Table 1: Section Numbers for each Deconstruction

Functionality	Site		
	Facebook	**Orkut**	**Twitter**
Public messaging	3.4.1	3.4.2	3.4.3
Microblogs	3.4.4	3.4.5	3.4.6
Photo sharing	3.4.7		N/A
Groups	3.4.8	3.4.9	3.4.10

3.4.1 Deconstruction of Public Messaging on Facebook (the 'Wall')

As described, social sites often provide a 'wall', 'whiteboard' or 'scrapbook', where friends and the profile-holder can leave notes. Variations include the ability to augment these notes with HTML formatting or images.

Surface elements:

- a box for up to 1000 characters of plaintext
- a 'share' button
- a list of previous messages and activity by the person whose wall this is, most recent first

Literal experienced effects:

- quick and easy
- communicating (one to one)
- being overheard

Abstract experienced effects:

- social connectedness (conversing, or letting someone know they are in your thoughts)
- anticipation of a response
- uncertainty (will there be a reply? When? Who else will read the message, how will they respond?).

Reconstruction of this functionality must account for the above elements and effects. An implementation accounting for this deconstruction might provide a very simple, clean interface for entering public messages and clarity that the message is public (through showing previous messages left by other people, and perhaps on first use a brief explanation of the mechanism).

One way to implement this in a new context might be to install a microphone and speakers on the door of someone's office. Passers-by may press a button to record a message for the office's owner ("Hi Andy! I dropped by to chat about X, but you weren't here. Catch you later!"); the last ten messages are played in a repeating loop. A time limitation (one minute, perhaps) reflects the character limits in the original medium.

3.4.2 Deconstruction of Public Messaging on Orkut (the 'scrapbook')

Public messaging on Orkut largely resembles the same on Facebook, although under a different name (the 'scrapbook').

Surface elements:

- a box for free HTML text, limited to 1024 characters
- three buttons: 'post scrap', 'preview' and 'add photo'
- a list of previous messages ('scraps'), most recent first

Experienced effects:

These are largely the same as those for Facebook, with two minor differences, both literal:

- quick and fairly easy, rather than quick and easy: the presence of three buttons (not one) make this process slightly more complex
- added expressiveness through HTML-rich formatting and the ability to include images

An appropriate implementation would be rather similar to that given in Section 3.4.1: differences involve people being able to preview their posts, and include images and more complex formatting with these. The inclusion of images can be reflected by making the set-up a display screen as well as audio equipment, such that audio-video recordings are made. Previews can be incorporated by adding a ten-

second time period after recording is complete, during which the most recent recording can be deleted by holding the button for several seconds.

3.4.3 Deconstruction of Public Messaging on Twitter ('@replies')

Unlike Facebook and Orkut, public messaging is carried out from the home page of Twitter, where users view the stream of tweets from sources to which they are subscribed. By contrast, the other two sites offer public messaging on the profile page of the recipient of the message:

Public messaging on Twitter is achieved via use of the @reply mechanism: users type their message, which like a microblog entry is limited to 140 characters, but include the text @username to direct the message at the person with that username. For example, "@bill Are we still on for tea at 10?"

Surface elements:

- a plaintext box for up to 140 characters of free text
- one 'update' button
- a list of previous messages, most recent first
- knowledge of the username of the recipient, and the @reply mechanism

Experienced effects:

These are largely the same as those for Facebook. The main differences is the ease of use: there is an additional load due to the requirement of understanding the @reply mechanism and knowing the username of the recipient. However, users can send public messages from the Twitter homepage, rather than having to navigate to the profile page of their would-be recipient.

When considering reconstruction, one must consider that like Facebook and unlike Orkut, public messaging on Twitter involves plain text only: additionally, updates are limited to 140 characters. Obvious changes to the existing reconstruction would therefore be to enable the leaving of audio messages limited to, say, 15 seconds in length. This does not quite capture public messaging on Twitter, however, as one would still have to walk to the office door of the recipient, whereas Twitter enables messages to be left from the homepage. Instead, the audio equipment could be in the reception of our office building, and people leaving messages must speak the name of their intended recipient for clarity.

3.4.4 Deconstruction of Microblogging on Facebook ('Status Updates')

Microblogging involves posting very succinct text updates, generally limited to 140 or 160 characters. Java et al (Java, 2007) suggest that the constraint on message size increases the speed of communication. They theorize that the constraint on message length lowers the time and thought investment from a

microblogger (as opposed to a traditional blogger); this is reflected by the fact that microbloggers tend to post more frequently than bloggers, perhaps daily rather than weekly.

The presentation of microblogging differs in different sites: for example, it is foregrounded in Twitter (where it is the primary functionality), but mixed with other information in Facebook.

Surface elements:

- a box for a limited amount of free plaintext (420 characters)
- a 'share' button
- a list of previous microblogs updates (your own, or others')
- buttons with the option to add URLs, images, videos or application-specific materials

Literal experienced effects:

- fairly quick and easy
- communicating (one to many)
- broadcasting information

Abstract experienced effects:

- presence in the community – consolidate online identity by adding more data
- openness about current experiences
- anticipation of responses
- uncertainty about responses and audience: especially if privacy settings are low, and anyone can access the content. Even if a very specific group of people can access the content, it is not guaranteed that they will do so, and thus uncertainty remains

Reconstruction of these elements and effects in a new environment would again include a very simple design allowing the composition and posting of microblogs. It is important to incorporate clarity about the audience, as controlled by privacy settings such as "friends only", "friends of friends" or "anyone".

One reconstruction of this functionality might see the microblogger wearing a t-shirt which incorporates a scrolling text display[4] displaying their most recent post, although this does not capture the ability to incorporate graphical information.

3.4.5 Deconstruction of Microblogging on Orkut ('status updates')

Microblogs on Orkut are presented a little different than on Facebook: there appears to be no history of previous status updates.

[4] Such t-shirts are currently on the market: they use thin battery-powered LED displays to show short messages.

Surface elements:

- a box for a limited amount of free text (140 characters), which can include emoticons selected from a dropdown list (nine emoticons available)
- an 'edit' button (this is also used to make the first, fresh post)

Experienced effects:

Again, experienced effects are largely similar to those associated with microblogging on Facebook, although updates to the status seem simpler here, as there are fewer formatting options (e.g. no option to include images). As such, a similar reconstruction seems appropriate.

3.4.6 Deconstruction of Microblogging on Twitter ('Twittering')

Twitter is often presented as a platform primarily for microblogging: certainly, the option is foregrounded on this website, which presents the tools for posting updates at the top of the homepage. It is worth noting that the surface elements of microblogging on Twitter are almost identical to those for public messaging: indeed, public messaging is achieved by using microblogging in a slightly different way (see Section 3.4.3).

Surface elements:

- a box for a limited amount of free plaintext (140 characters)
- an 'update' button

As with Orkut, experienced effects are very similar to those found with Facebook, although again, the act of posting an update is even quicker and easier than either of the previous two platforms, as there are no options to add URLs, videos, emoticons or similar. Again, therefore, a similar reconstruction seems appropriate.

3.4.7 Deconstruction of Photo Sharing on Facebook and Orkut

The majority of the sites surveyed allowed users to upload and caption photos, which can be commented upon by the photo's owner or other users. Some sites, including Facebook and Orkut, allow users to 'tag' friends in photos, adding metadata which links images with people's profiles. Both Facebook and Orkut allow photo upload, captioning and tagging. Indeed, it would appear that surface elements and experience effects are nearly identical between the two sites, as both offer basically the same functionality.

Surface elements:

- a (generally complex) photo upload process
- the option to annotate images with text

- the option to ‘tag’ images (indicate which contacts are displayed)
- the ability to view photos

Literal experienced effects:

- broadcasting information
- sharing past experiences

Abstract experienced effects:

- presence in the community – consolidate online identity by adding more data
- openness about past experiences
- anticipation of discussion about these experiences
- reminiscence
- uncertainty about responses and (depending on privacy settings) audience

Again, reconstruction should incorporate the above items. There must be a method for placing photos (and annotations) in the shared space, perhaps involving photo selection via an appropriate interface (e.g. computer monitor; TV screen; digital photo frame). Users must be able to browse and annotate their online photos, and be notified if people comment. These functionalities combine to allow users to feel that they are sharing memories.

A reconstruction might involve a novel tabletop which displays a sequence of photographs uploaded by the table’s owner.

3.4.8 Deconstruction of Groups on Facebook (‘Groups’)

Online groups enable people with shared interests to maintain contact. It is worth noting that groups (also described as ‘communities’ or ‘forums’ – although the word ‘forum’ can also refer to a specific format of webpage which supports threaded discussions) constitute a wide array of functionality, from browsing and searching to find groups, to viewing groups recently joined by friends, to viewing very active groups. For the purposes of this deconstruction, we consider the experience of searching for and joining a group about line dancing.

Surface elements:

- a plaintext box to enter search text
- a ‘search’ button
- after searching, a list of matched results: this list displays for each group a title, icon, number of members and type (e.g. “Entertainment & Arts – Dance”). It also includes recent activity (e.g. “3

More Members, 1 Wall Post"). Each group has a link, allowing the user to either join the group, or request to join subject to admin acceptance.

- after clicking on a group, the group's webpage is shown: this is akin to a person's profile. It contains the above data and a description, contact details, location, discussion board, admins, members, recent news, public message area, photos, links, videos and related groups.

Literal experienced effects:

- quick
- subject to suitable search text, easy
- availability of relevant communities
- availability of information about these communities – e.g. popularity (based on membership numbers) and activeness (based on recent activity)
- ability to join these communities

Abstract experienced effects:

- potential connectedness and online presence

Many hobby groups and communities exist in the physical world, but the process of searching for these is less simple than online. One analogy to the above is browsing through listings in a local newspaper: however, this does not include common classifiers of the groups on offer, nor information on recent activity – not to mention that the activity is browsing, not searching.

An appropriate reconstruction might involve building a database of information on local community groups, and enabling search-based access to this via a number of interfaces, including via the web and smart phones. Recent information on shifts in membership would be difficult to maintain, as it would require regular updates from each group: an alternative way to get a gauge of the popularity of groups would be to display the number of people who have looked up that group in the last month (or to allow a ratings system, like that used for sellers on eBay), while activity can be conveyed by including information on how frequently the groups meet. Similar descriptors to those above (descriptions, contact details, photos etc) can be stored in the database, and made available to searchers.

3.4.9 Deconstruction of Groups on Orkut ('Communities')

Searching for groups on Orkut is not dissimilar to the same experience on Facebook, but differences do exist. Differences are shown below:

Surface elements:

- after searching, a list of matched results, first showing groups in the user's country, then showing groups worldwide. For each group, the list displays a title, icon, category, location, number of members and brief description.
- After clicking on a group, the group's webpage is shown. This has the above data and language, owner, type (public, moderated, validated), content privacy (open or closed to non-members) and creation date. If they exist, the group's forums (with topics, number of posts, and date of last post), polls and events are displayed.

Experienced effects:

These are largely the same as those for Facebook, with minor differences:

- information about how active groups are is less obvious (but exists upon clicking on a search result)
- joining is slightly harder (one must click on a community from the search results in order to then join it)

As such, a reconstruction of the experience of searching groups in Orkut would be largely similar to reconstructing the same action in Facebook.

3.4.10 Deconstruction of Groups on Twitter ('#hashtags')

As with public messaging, the functionality associated with implementing groups is different on Twitter to Facebook and Orkut. Twitter uses hashtags, inline to microblogs posts, by prefixing words with the has symbol. For example: #interest. Example uses suggested by Twitter are to collate Tweets relating to

- events or conferences (e.g. "Tara's presentation on communities was great! #barcampblock")
- disasters ("#sandiegofire A shelter has opened up downtown for fire refugees.")
- context ("I can't believe anyone would design software like this! #microsoftoffice")
- recall ("Buy some toilet paper. #todo"), and
- quotes ("Great minds discuss ideas. Average minds discuss events. Small minds discuss people. ~Eleanor Roosevelt #quote").

As such, groups on Twitter work somewhat differently to groups on Facebook or Orkut, primarily adding context and metadata, like tags, enabling like-tagged posts to be collated. By contrast, groups on 'heavier' social sites have a specific membership of users, along with functionality such as public messaging, photo-sharing and so on.

It is worth noting that it is quite difficult to find documentation of the hashtag functionality on Twitter, without obvious links on the main help pages. However, at least two web pages exist from which

hashtag groupings can be browsed or searched: http://hashtags.org/ and http://twittgroups.com/. Both sites offer search experiences:

Surface elements:

- a plainbox to enter search text
- a 'search' button
- knowledge of the #hashtag mechanism
- after searching using hashtags.org, a list of matching tags and messages. Clicking on matching tags shows all messages with this tag.
- (this effect applies not to Twitter but to the augmented functionality provided by TwittGeroups.com): after searching using twittgroups.com, a list of groups which match this the search term are shown: each has a title, brief text description and URL. Clicking on a group shows further information (description, icon, etc.; also public messaging and a list of members) and an option to join: clicking on 'join' opens a new Twitter window with a pre-written message stating you have joined the group, ready to be submitted via the 'update' button.

Literal experienced effects:

- quick
- subject to suitable search text and knowledge of the #hashtag mechanism, easy
- availability of relevant communities/activity around this topic
- knowledge of popularity of this topic, based on quantity of results
- ability to join communities

Abstract experienced effects:

- potential connectedness and online presence

Note that the Twittgroups website appears to be trying to provide more traditional 'groups' in the sense of the interpretation found on sites such as Facebook and Orkut, by augmenting the functionality with items such as public messaging, member lists and so forth. However, functionality provided by Twitter alone is that available via the Hashtags site, and it is this which we should consider for reconstruction.

This experience boils down to seeing all recent public posts which are tagged with the search term. A reconstruction must enable people to enter search text and access the relevant information: one approach might be to allow people to type their term into a dedicated keyboard situated beside a microprinter (or select images which represent concrete search terms, such as 'oak trees' or 'family'): the microprinter promptly prints matching tagged Tweets. An augmentation would be a switch which when in one

position means searches are confined to hashtags, and when in the other means that searches cover all messages. One can envision a parallel implementation whereby companies have 'buckets' of relevant Tweets: for example, an IBM reception might have a container below a printer which dispenses in real-time slips of paper printed with Tweets about the Smarter Planet initiative.

3.5 Summary and Discussion of Results

Section 3.4 presents a systematic application of deconstruction across a set of social sites and functionalities. This section summarises these deconstructions (in Table 2), and discusses them.

It can be seen that the elements and effects associated with public messaging are very similar across all three platforms, although different levels of message richness are available according to the presence of HTML formatting and graphics – and message length. These differences are reflected in the suggested reconstructions.

Deconstruction of microblogs and photo sharing also yielded very similar elements and effects across the sites, and the Facebook and Orkut approach to groups was similar. The Twitter implementation of groups differed, being based on tagged microblog posts rather than users explicitly signing up to a particular community. In a not dissimilar vein, the Facebook and Orkut implementation of functionality for groups was generally rather similar, while the Twitter approach differed, using a microblogging-based mechanism to achieve community.

It can be seen that Facebook and Orkut generally presented very similar experiences: this similarly can also be seen in Appendices A and B, which show both sites providing similar functionality and profile breakdowns. The two sites do show some differences in their implementations of functionality, for example with Orkut's implementation of public messaging allowing richer material to be expressed.

One might notice that there is a blurred line between Orkut's public messaging (called 'the scrapbook' on the site) and Facebook's microblogs entries (or 'statuses'): the former allows 1024 characters of HTML-rich text, with images, while the latter allows 420 characters of plaintext, with URLs, images, videos and application-specific data. Unlike public messages on Orkut, a Facebook microblog entry is constrained to the user's profile, and cannot be left 'with' other people, but the richness of the content of each item is matched.

Twitter is clearly more different than the other two platforms. It does not allow photo-sharing, providing instead very lightweight mechanisms for public messaging, microblogging and groups. All of these are achieved via the same textbox and button on the homepage: public messaging and groups occur via the use of Twitter-specific mechanisms, @replies and #hashtags. The deconstructions in Section 3.4 make a note of the requirement that users understand the @reply and #hashtag mechanism, without specifying that users must understand how to use textboxes and buttons: this is precisely because @replies and

Table 2: Summary of Deconstruction

Functionality	**Site**		
	Facebook	**Orkut**	**Twitter**
Public messaging A space for the profile holder and contacts to leave notes: sometimes plaintext-only, sometimes richer.	*Elements*: textbox, button, list of prior messages *Effects*: quick/easy, communication (one-to-one), social connectedness, being overheard, anticipation of response, uncertainty *Recon*: audio messages recorded, situated on office door, play in loop	*Elements*: textbox, buttons, list of prior messages *Effects*: as Facebook, but not quite as easy (more buttons, can preview); added expressiveness, HTML-rich text, graphics. *Recon*: similar to Facebook, but enable previews and video data	*Elements*: textbox, button, list of prior messages, know recipient's username, @reply mechanism *Effects*: as Facebook, added load (need prior knowledge) but functionality is available on homepage *Recon*: as Facebook, but shorter messages, situated publicly (people must specify recipients' names)
Microblogs Succinct text updates, generally limited to 140 or 160 characters	*Elements*: textbox, button, list of prior posts, further options *Effects*: fairly quick/easy, one-to-many communication, broadcasting info, presence online, openness, anticipation of response, uncertainty *Recon*: t-shirt with scrolling text display of most recent post	*Elements*: textbox, button *Effects*: generally as Facebook *Recon*: as Facebook	*Elements*: textbox, button *Effects*: as Facebook, although even quicker/easier due to lack of additional options Recon: as Facebook
Photo sharing The ability to upload and caption photos, which can be commented upon	(Merged cells because functionality is effectively identical across both sites.) *Elements*: complex photo upload process, option to annotate images, option to tag images, ability to browse photos *Effects*: sharing past experiences, broadcasting information, presence online, openness, anticipation, reminiscence *Recon*: novel tabletop displaying a sequence of photos		N/A - not provided
Groups: specifically, searching for and joining a group Also called communities or forums: a mechanism for groups of like-minded people to make or maintain contact.	*Elements*: textbox, button, list of results which links to group webpages *Effects*: quick, easy if used suitably, community availability, ability to join communities, potential connectedness and presence *Recon*: search a DB about local community groups via web or smart-phone interfaces, including access to info on meeting regularity and popularity of groups.	*Elements*: as Facebook, although list of results priorities groups within the user's country *Effects*: as Facebook, although it is harder to gauge how active groups are, and to join them *Recon*: as Facebook	*Elements*: textbox, button, use of #hashtag, list of matching tags and messages *Effects*: quick, easy if used correctly, community availability (and popularity) and activity, potential connectedness/presence *Recon*: user specifies search concept, microprinter churns out matching Tweets

#hashtags are indeed specific to Twitter, and not found elsewhere. By contrast, the other technologies which are deconstructed are commonly found upon the web.

It is of note that the distribution of abstract and literal experienced effects varied across the deconstructions: for example, deconstructions of public messaging and microblogging showed generally equal numbers of abstract and literal experienced effects, but the deconstruction of photo sharing showed more abstract elements, while the deconstructions of groups involved more literal elements. (It is interesting, too, that these distributions held across platforms, but varied across functionalities.) This could well be due to the nature of the functionalities considered: photo sharing is an activity associated with feelings and impressions, and thus is perhaps a more 'abstract' experience than the activity of searching for a specific community online.

Having deconstructed various aspects of functionality across different platforms, one can consider the overall social networking experience. Microblogging augments people's profiles, helping them equate to a physical presence by facilitating a sense of presence in the online community. Messages roughly equate to spoken conversations, held in public or private, and enhance communication and social connectedness. Photo sharing is similar to seeing the moments in question as they happen, or sharing physical photos: like sharing printed photos, it involves reminiscence, openness and sharing of past experiences. Groups appear to equate to active discussion forums, offering the potential for social connectedness and presence.

By including interactions between mutual friends and friends-of-friends, and by including text, images and groups, these websites begin to form a metaphor for village life. The sites instil a feeling of community and connectedness, not solely through direct chat, but through the combination of the above effects. A user on a social website won't generally just view a private message, or a photo, or a friend's status, but will instead see a combination of microblogs, images, messages, upcoming events, and so on. In a sense, they are seeing a personally-crafted, up-to-date bulletin board about their contacts, augmented with direct messages.

The functionality offered by social websites appears to map to various physical experiences such as conversation (direct or overheard), shared moments and seeing friends carry out actions. The overall effect is not unlike that of walking through a village populated by one's contacts, and observing (and participating in) actions and conversations.

Future work in this field could dig deeper into user awareness and understanding of social networking. For example, a public message thanking a friend for dinner is different from a private message with the same content: the former message broadcasts to friends of both parties that they had dinner together. How do experiences at each 'end' of a social interaction vary? That is, how do message senders and recipients experience matters? What about people who witness interactions between others?

3.6 Discussion of Deconstruction

In this section, we analysed Dix's method of deconstruction and broke it down into a simple methodology, which has been applied to several aspects of social networking websites, in order to better understand these aspects.

The deconstruction method provided useful information. Applying the method in a systematic, repeatable manner exposed emerging themes common across the items of functionality: for example, communication or sharing of material were common surface elements across the items considered. The public nature of each task is of note: experienced effects across all items include being open/overheard, anticipation of responses and not knowing who (beyond the intended recipient) will see the content. Lack of certainty about one's audience also increases uncertainty regarding what manner of response will result, and when.

Experienced effects are a useful tool for distinguishing between apparently similar actions. For example, our analysis of public messaging and microblogging included very different experienced effects (social connectedness compared to broadcasting information and consolidating one's online presence).

It seems likely that the elements and effects associated with each item of functionality are more widely experienced when using social sites. For example, not all actions directly consolidate one's online identity, but many do: consider microblogging, blogging, photo sharing and filling-in a profile.

As noted in Section 3.5, the distribution of abstract and literal experienced effects varied across the deconstructions, according to the functionality being deconstructed. It seems likely that the nature of experiences directs the proportion of abstract to literal effects associated with them, but further work would be required to investigate this area.

So, deconstruction is useful for comparing multiple items in order to elicit commonalities and differences. It is of note that deconstruction is an inherently subjective process, requiring that the designer considers what 'surface elements' and 'experienced effects' make up an experience. One way to make the method more robust might be to introduce multiple people in the process, offering more confidence that results are not the result of a single, biased perspective.

As well as finding the process useful for identifying themes, the author found the task of re-imagining experiences far easier having abstracted those experiences. For example, it seems like a very big step to move from 'microblogging' to 'a scrolling display on a t-shirt'. However, the steps from 'microblogging' to 'brief one-to-many communication' to 'a scrolling display' seem much smaller and more logical.

Further lessons learned are the importance of accounting for all aspects of an experience – that is, the experienced effects as well as the surface elements. It is straightforward to reason that a novel interface

should offer a similar surface design to its web-based equivalent; however, it is less easy to account for the emotional implications of a transaction, such as the expectation of replies.

Finally, it is of note that it is difficult to evaluate the success of deconstruction, because of its subjective, creative nature. One approach to evaluation is to deconstruct the reconstructed experience, and see whether the surface elements correlate appropriately, and produce the same experienced effects. Another approach involves producing a concise guide to deconstruction, and holding an expert review on this guide.

As noted in Section 3.1, experience deconstruction is not a traditional engineering approach, but rather a creative tool which is useful for understanding specific experiences and generating ideas for re-building these experiences.

3.7 Actor-Network Theory

This section presents Actor-Network Theory (ANT), explaining the gist of the theory, briefly demonstrating its use, and discussing its relevance to this research.

3.7.1 What is ANT?

ANT is another tool which can increase understanding: it models the flow of interactions and processes between actors as they are recruited into a network. An actor may be one or many humans, an artifact, standard, text or graphics. It gives a process-based perspective on interactions between users, and insight into how networks grow and are used to achieve goals.

ANT proposes four 'translation moments':

1) **Problematisation**: the focal (primary) actor becomes interested in an issue, and identifies a possible solution.
2) **Interessement**: the focal actor convinces other actors that the issue is relevant to them. They consider involvement and possible roles.
3) **Enrolment**: other actors join the network.
4) **Mobilisation**: enrolled actors take action to resolve the issue.

ANT is described as a 'material-semiotic' method, meaning it maps relationships that are both material (between things) and semiotic (between concepts). It assumes that many relations are both material and semiotic: for example, a sales transaction involves people, their ideas and technologies. This property is useful when considering online exchanges, which are both material and semiotic in nature.

ANT is also useful as it can offer different perspectives. For example, it can be used to model a bank as a network and also as a single entity within a larger network. This property allows us to consider individual facets of social networking (such as photo sharing and public messaging) as well as social networking as a whole. The following examples show this change in focus.

3.7.2 Two Examples of ANT in Action

A perspective which views one social site as a network is sign-up to social sites. Sign-up can be mapped to ANT's translation moments:

1) **Problematisation**: our focal actor, Alice, wants to share photos (or contact people for whom no email addresses are held; or advertise an event). She uploads images to a social site.
2) **Interessement**: Alice contacts her friends to tell them the photos (or text, event details etc.) are online. Her friends weigh up the costs and benefits of joining the social website.
3) **Enrolment**: Alice's friends begin to sign up to the website. The more mutual friends using the site, the greater the benefit of joining.
4) **Mobilisation**: friends on the website access the shared information.

Alternatively, ANT can be applied to facets of social networking, such as photo sharing:

1) **Problematisation**: Alice has an unfulfilled desire to share her holiday photos with her friends.
2) **Interessement**: Alice posts the images online and perhaps notifies some of her friends.
3) **Enrolment**: Alice's friends begin to look at and comment upon the photos, which may raise the profile of these photos (as news feeds can include, as well as "Alice uploaded a photo", "Bill commented on Alice's photo").
4) **Mobilisation**: more comments generate more interest.

3.7.3 The Relevance of ANT for Understanding Online Social Phenomena

As can be seen, ANT can be applied in different ways. It is clearly suited to specifically modelling the evolution of networks, whether those networks are the membership of one social site (e.g. all Myspace users), the nuances of a network within such a site (e.g. campaigners for a political cause on Facebook), or the relationship between multiple social sites (the overall landscape of social networking sites).

ANT can also be used to model an individual: it is not intuitive to consider 'an individual using a social site' as a network, but it is possible to describe a network made up of the human user, their online photographs, their microblogs updates and so forth. In this respect, ANT may be a powerful tool for considering the way in which people build online identities.

ANT is not useful for modelling every aspect of online social transactions. For example, Hart has observed that people tend to 'hang around' on social sites and see what's happening (Hart, 2008), which links with some of Gaver's comments (Gaver 2004): use of social websites appears to be a ludic activity, motivated by curiosity, exploration and reflection. This holistic browsing of sites is a contrast to someone logging in, solving a specific problem and logging out: it is this latter type of action which ANT is best suited to modelling.

ANT is useful for discerning and demonstrating the ways in which all of these networks evolve over time, and thus it can be used to complement in-depth information about individual items and actions, as analysed by techniques such as Experience Deconstruction.

4 Multimodal Messaging Infrastructure

The envisioned social fabric requires an underlying messaging infrastructure. This section describes the motivation for the messaging system, outlines some relevant literature, and then describes the envisioned system and current prototype, before evaluating the prototype (Owens, 2009b).

To attain the goal of greater availability of social technologies, it is vital to decouple information from its original modality. For example, the content of a chatty email is the text, which as well as being displayed on a computer monitor could be printed out, displayed on a television screen or vocalised on a landline phone with text-to-speech technologies.

This decoupling of content from modality allows people much greater flexibility in terms of what information can be received when. It allows a user, Alice, to stream her voicemail to her PC if she has forgotten to bring her mobile phone to work, and means that she can email her grandfather Derek, even though he doesn't own a PC. Derek can access direct messages such as emails and SMSes, and also more ambient social information (e.g. microblogs or shared photographs) from his family members. Figure 2 and Figure 3 show how a multimodal infrastructure can enable this decoupling.

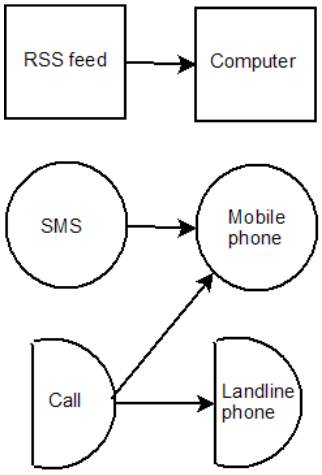


Figure 2. The current situation, where message modality constrains the devices upon which the message can be received.

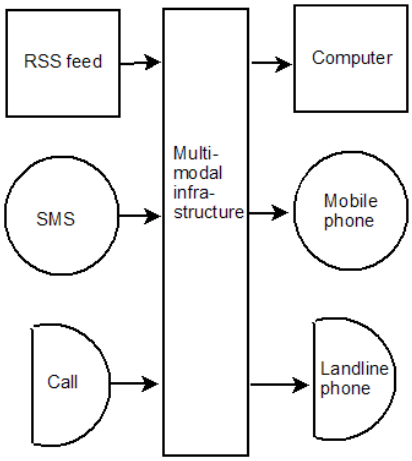


Figure 3. The vision, where message content is decoupled from its modality: content can be sent to any device.

To provide this functionality in an appropriate way, incoming information must be carefully managed. Any infrastructure able to choose the most appropriate modality must be able to account for a person's context – for example, their location, current activity and priorities (which may concern mode of communication and intrusiveness).

Several components are needed to realise this vision. Firstly, an underlying pervasive messaging model allows transport of information between locations, and translation between modalities: this system must understand channels such as email, IM and audio data. Secondly, a formal user information model (user

proxy) captures a user such as Alice, her relationships with others, preferences for modality, and rules (such as not being phoned between 11pm and 7am).

4.1 Related Work

Various proposed and implemented systems have looked at pervasive communication infrastructures. For example, the Mobile People Architecture (Maniatis, 1999) embodies a vision where people, rather than their disparate devices, are the endpoints of communications. A 'personal proxy' tracks user locations, and accepts, converts and forwards communications as appropriate. The concept of Universal Communication Systems, which combine various modalities of communication (Andrews, 2001), is not a new one. Examples include: email notifications about voicemail (Liscano, 1997); a 'console' for group conversations via SMS, email, IM and the web (Heyer, 2008); and a proposed system to route emails and phone calls dynamically according to user context (Kamioka, 2004). Similarly, Nakanishi et al have prototyped a system to redirect calls and emails based on people's schedule, location and available devices (Nakanishi Y, 2002).

The Iceberg architecture (Wang, 2000) aims to integrate cellular telephony networks and the internet. The Universal Inbox (Raman, 2000) uses this to redirect communication based on pre-defined user preferences. Active Messenger (Marti, 2001) routes email to pagers, phones and faxes, based on calendar and other contextual information. It allows users to define preferences according to their location and the time of day. Another implementation, Mercury (Lei, 2004), integrates phones, IM, email and pagers.

Despite this work, progress in the real world has been slow, perhaps due to the challenges of implementing this technology in the wild. Turk (Turk, 2005) notes the need to integrate channels and address privacy issues, whilst Branco (Branco, 2001) raises questions such as what data helps ascertain user context, and how best to map content for impaired users.

Recent developments in social communication, such as microblogging and instant photo sharing, have introduced new requirements to these communication systems. We are still in the process of understanding user attitudes and behaviour on popular platforms such as Twitter, and social networking websites such as Facebook or MySpace. Unlike email, SMS and IM, these technologies are not primarily about direct messages, but a more ambient awareness, and so they must be treated differently in the context of multimodal communications.

This work differs from existing designs and implementations in several respects. Firstly, the vision isn't only about routing direct communication, but also information about the wider world (RSS feeds and sensor data, e.g. electricity usage or car mileage) and personal data (reminders and ambient awareness of

friends' activities and wellbeing, achieved with text and photographs through social networking mechanisms such as Facebook).

Thus, the system can route two types of data:

1. personal data, to which access requires verification (e.g. direct communications such as email and text messages and ambiguous communication such as social networking data)
2. publicly available regularly-updated material, such as Twitter streams (see: http://twitter.com/), blog posts, sensor data and other items on RSS feeds

The system will allow different levels of notification, from viewing new information only upon explicitly logging into the system to being woken in the night when an urgent message arrives. The system has a very broad audience: users may own PCs or mobile phones, but they need not. Anyone with a device which can interact with the system would be able to use it, including owners of older technologies such as televisions or landline telephones. Additionally, the emphasis on the assistive nature of this technology naturally leads to an approach of inclusive design, involving stakeholders where possible (Newell, 2004).

4.2 Envisioned System

A future system will allow people to browse or search a list of publicly available items such as RSS feeds and Twitter streams, and subscribe to private streams such as email accounts and text messages (SMSes). To subscribe to private items, users must provide verification, such as a username and password for email and IM accounts, and a text from the relevant mobile phone for SMSes. Non-PC users would enter this data in novel ways. A teletext-like interface on televisions could offer one method of system configuration, while voice recognition technologies would enable configuration via landline telephones.

The envisioned system will use whatever available technology there is to determine user location: this might include the current cell of a mobile phone, the wifi network used by a PDA, or sensor data (e.g. a broadcast car location). Additionally, users may explicitly notify the system about their current location. At the moment, locations and subscriptions are initially set up in an XML file, and may be edited via the GUI.

Users may have one of three levels of linkage with any given location. They may choose to be 'offline', in which case messages are not routed to them, but queued until they return online; they may be 'guests', and logged into the location – but their information is discarded when they leave; finally, they may be durable guests, in which case their preferences are remembered for future visits.

A more advanced system will carry out some transformations so as to deliver the data in an appropriate format. For example, most emails won't fit into a 160-character SMS, but a text message detailing the sender, subject line and first *n* characters of content might be appropriate. The method and nature of transformations is an area requiring further attention, although existing work has made inroads in this area: for example, Nagao et al have discussed content adaptation based on available devices (Nagao, 2001).

Current preference lists, which rank modes of communication, are linked to people's locations. Later, they may have additional constraints relating to time, people and events. For example, Alice may not want to receive phone calls between 11pm and 7am (time); unless they are from her partner, Bill (people); but if she is at a doctor's appointment (event), she may not want to receive any calls at all.

Users may in future also list 'trusted contacts', who can receive limited information from the envisioned system about the person's context. For example, it is useful for Bill to know that Alice has received a text notifying her of his 1000-word email, but Alice has to list him as a trusted contact in order for him to be told this.

Finally, other changes might include enabling preferences for environments and events. For example, it may be appropriate to suppress the ring tone on mobile phones in cinemas, or meeting rooms in current use. In contrast, an open-plan office environment may allow soft beeps but nothing above a certain volume. Event preferences might be relevance to, for example, film screenings (where incoming messages may be blocked): in this instance, provision of an emergency phone number may be appropriate. For example, if Alice's mother is taken into hospital whilst Alice is at the cinema, a phone call or SMS will not reach her. However, it may be possible to have a cinema employee find Alice in person.

The interaction of preferences is an area for future work, particularly if environments and events also have preferences. If two people meet, how do their preferences affect one another? Alice may not want interruptions, but Bob may be happy to receive these; meanwhile, Carol may not want to receive messages from Debra if she is with Evan. It is likely the logic to deal with this would reside with the proxy of each person: for example, Carol's proxy may be aware that messages from Debra should not be propagated if Evan is present, and Carol may have marked meetings with Evan so that her proxy knows when to delay Debra's messages.

4.3 Prototype System

The current prototype uses IBM's Lotus ® Expeditor micro broker to convey messages and is coupled with a simulation environment. It demonstrates the soundness of the underlying logic and model, and enables exploration of scenarios.

The system receives incoming information (which in future will be from websites, email inboxes, sensors etc.) and delivers it to an appropriate end point. End users shouldn't have to concern themselves with the type of a message: whether the content was sent as an SMS, email or Tweet need not affect when and how it is received. Currently people may choose a different modality for message sending according to message priority. For example, if Alice's friend Bob is in the cinema, she may send him a text message but not phone him. This system aims to eventually remove that load.

4.3.1 Using the Prototype

A screenshot of the current simulator can be seen in Figure 4, below. The simulator provides a listing of information from the world as modeled by the system: this list describes the time, devices, people, locations, data sources and events within the world. The right hand side contains controls for changing the state of various items within the world: it is possible to change a person's location and subscriptions, to send messages, and to change the time in the world. Below these controls are a change log (which records button presses) and a message log (which records the result of publishing messages).

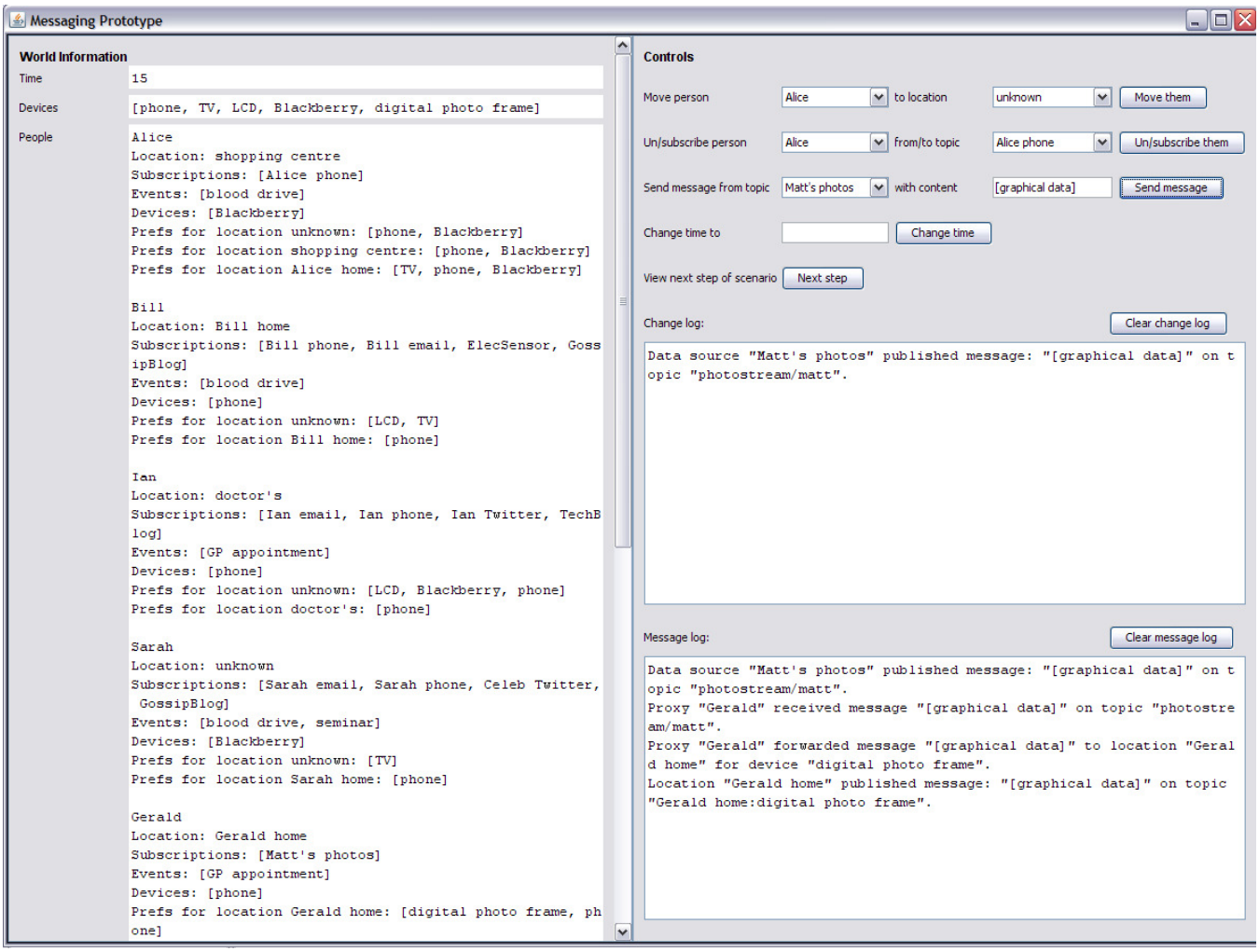


Figure 4. Screenshot of simulator.

These controls allow users to see how messages traverse the world. By changing the subscriptions and location of a person, one changes which messages they will receive, and where. For example, as shown in the screenshot, it is possible to walk through aspects of scenarios, such viewing what happens when Matt publishes photos on the stream to which Gerald is subscribed.

Note that aspects such as the current time and events can affect message receipt. When the system doesn't know where a person is, it checks to see whether they are currently attending an event: if so, it reasons they are at the event's location, and tries to send the message accordingly. If no suitable devices are available upon attempted message delivery, the proxy of a given person will queue the message for later delivery.

4.3.2 Messaging Paradigm and Technology

The prototype uses IBM's micro broker middleware for message transfer (Gale, 2007). Middleware provides connectivity between networked applications and software, while micro broker is a publish and subscribe (pub-sub) message broker appropriate for a variety of applications, especially in mobile and

pervasive domains. Messages travel between brokers, which determine which recipients receive which messages. Pub-sub is one of two approaches to describing destinations in pervasive messaging:

1. Point-to-point messaging: publishers specify message recipients, and place messages on those recipients' queues. This routing does not take advantage of common paths, and becomes inefficient when there are many subscribers (Banavar, 1999).
2. Pub-sub messaging allows delivery of one message to many subscribers. Subscribers may register interest in a 'topic' (message destination or queue), and then receive messages sent to this topic.

Given the inclusion of one-to-many data sources such as sensors, blogs and RSS feeds, the pub-sub paradigm is most suited to our model.

The prototype system is written in Java™ and uses IBM's micro broker middleware. It models a real-life implementation in which broker instances deal with subscriptions and publications. Brokers can handle many connections at once. For example, an instance of micro broker can handle around 2000 connections at any given time: for our purposes, this system is scalable.

The user proxy is an application subscribed to the individual's streams of information and relevant notification channels (e.g. regarding location and available devices).

4.3.3 System Model and Logic

Figure 5 shows a class diagram of the prototype system. As can be seen, the `Proxy` class is central: instances thereof represent an individual end user. This class has various properties, including preference listings (where each `PrefList` denotes preferred communication channels for a given location), a current location, any events the person plans to attend, and a list of `DataSources`, the items to which the person is subscribed. This class also contains a listing of devices on the person, and any queued messages for the person.

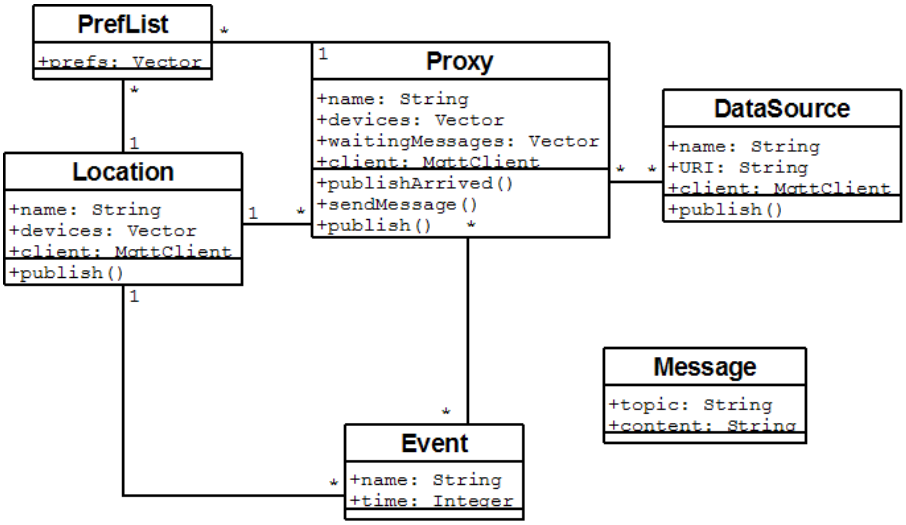


Figure 5. Class diagram

Users can have as many PrefList items as they want. It is recommended that every user has one PrefList with no specified location: this is used as a default, if they are in a location for which no PrefList has been defined, or their location is unknown. If someone doesn't wish to receive information via a certain delivery mechanism, they simply do not list relevant output devices.

A `Location` has a name and a list of devices which are present, while an `Event` is a combination of a location and time, with a name. Example events include clinic appointments, tea dates and film screenings. `DataSources` have a name and URI, and can publish messages to that URI. `Messages` have a topic (the URI to which the message was published) and content. Messages may be written and published via the GUI.

Note that `Locations`, `DataSources` and `Proxies` all have `MqttClients`. `DataSources` and `Locations` use these to publish messages. `Proxies` also publish with their `MqttClients` (to the topics of devices located upon the person they represent), and use a `publishArrived` method to receive incoming messages.

Proxies carry out the logic of running through a person's preferences for modality, and poll the person's current environment for available options, sending the information as appropriate. When a message is received, the proxy's `sendMessage` method is called. In this method, the proxy works through several steps:

1. If the current location is unknown, check events for this person: if the person should currently be at an event, set their current location to that event's location.

2. Try to find a preference listing for the current location; if there isn't one, use the default preference listing (for the 'unknown' location). If there is no default preference listing, throw an error.
3. Iterate through the preference list: look up the most preferred device. Check if an instance of the device is available, either on the person or in their current location. If so, send the message to that device's URI; otherwise, check the next most preferred device. If a message cannot be sent (no preferred devices are available), add it to the Proxy's `waitingMessages` Vector.

As described, `Proxies`, `Locations` and `DataSources` run instances of `MqttClient` in order to publish messages and subscribe to topics. A broker can handle many connections at once; an instance of micro broker can handle around 2000 connections, which is scalable for our purposes.

4.3.4 User Preferences

Users can build lists to rank communication channels in order of preference. For example, Alice's list `[speakers, TV]` means that Alice prefers to hear information from loudspeakers; if these are unavailable then she wants to access it on a television.

Preference lists generally relate to specific locations, meaning that users may build multiple lists: it is likely that Alice wishes to receive notifications about a friend's activities in different ways depending on whether she is at work or at home. A 'default' preference list applies if Alice is in a location for which no specific list exists.

4.3.5 Sequence Diagram of the Scenario

Figure 3 showed the simulator demonstrating the beginning of the given scenario. The following sequence diagram shows the beginning of this transaction.

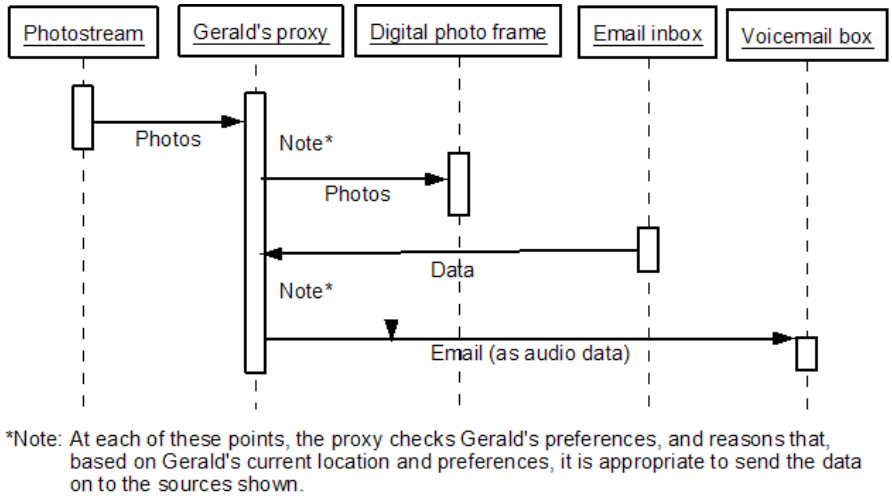


Figure 6. Sequence diagram. A proxy transforms and routes incoming material based on user preferences.

4.4 Scenario-Based Evaluation of Prototype

This subsection provides a scenario-based evaluation of the prototype system. This section demonstrates that the underlying multimodal model is fit to support the scenario described in Section 1, describes the scenario built into the prototype, and finally discusses how the prototype can be extended to support more sophisticated scenarios.

4.4.1 Scenario in Section 1

Section 1 provides an initial scenario to demonstrate the author's vision. The prototype system supports the functionality described in this scenario, which includes:

- viewing data from an online photograph stream on a digital photo frame
- receiving email content via a telephone or other device (note: the device type 'microprinter' is not incorporated into the current model, but adding this is trivial. See Section 4.4.3 for more on this)
- sending voice messages without needing to know how or when the recipient will access these
- following online updates via a television display

4.4.2 Scenario Provided with Prototype

A scenario is built in with the prototype's GUI simulator, designed to be used with the '`worldinfo.xml`' file. This file describes a world including the character Bill, a few locations he may travel to, his subscriptions, preferences and devices. This scenario may be accessed by clicking the 'Next step' button, beside the text saying 'View next step of scenario'. Its purpose is to easily demonstrate how the system might affect one person in the course of a day.

The scenario is thus:

It is 8am, and Bill is at home. Bill receives an email, which is published to his phone (his preferred – indeed, only listed – device for receiving messages at home). 9am comes, and Bill is now at his workplace, IBM. The morning passes, and midday arrives. At this point, a phone message arrives for Bill, which is routed to the LCD at IBM: the LCD is chosen as Bill hasn't listed preferences specifically for IBM, but the LCD is top of his default list (under 'Prefs for location unknown' on screen).

More time passes, at it is 1pm. Bill's location changes to unknown: he has left IBM, in fact to head to the university, which is holding a blood drive at 2pm. Come 2pm, Bill's electricity sensor publishes an update. Although Bill's location is still set to unknown, the system reasons that he is at university, as it knows he plans to attend the blood drive: the sensor update is delivered to the LCD at the university.

Now, it is 4pm, and Bill receives an email. Unfortunately, the system has no idea where Bill is: his location is set to 'unknown', and he is not attending any current events. The message is queued for later. When the time is updated to 5pm, the system again tries to send Bill's message, checking his events to see if his location can now be inferred: it cannot, and so the message remains in Bill's queue. Note that Bill has a phone on his person throughout this: however, according to his preference lists, he only wishes to receive phone messages when at home.

It is now that Bill goes home, and the waiting email message is transmitted to his phone. Next, the time is updated to 7pm, and the 'GossipBlog' data stream publishes an update. This is propagated to Bill's phone (and also to Sarah's Blackberry, as she too is subscribed to this stream).

The scenario can also be viewed step-by-step, where each new step is triggered with another click of the 'next step' button:

1. Set time to 8am.
2. Set Bill's location to Bill home.
3. Publish data on "Bill email" stream.

4. Set time to 9am.
5. Set Bill's location to IBM.
6. Set time to 12pm.
7. Publish data on "Bill phone" stream.
8. Set time to 1pm.
9. Set Bill's location to unknown.
10. Set time to 2pm.
11. Publish data on "ElecSensor" stream.
12. Set time to 4pm.
13. Publish data on "Bill email" stream.
14. Set time to 5pm.
15. Set Bill's location to Bill home.
16. Set time to 7pm.
17. Publish data on "GossipBlog" stream.

Note that pressing the 'next step' button again will trigger a message in the change log to the effect that the scenario is ended, and pressing the button again will restart the scenario.

4.4.3 Supporting More Complex Scenarios

One may consider more sophisticated scenarios, such as the following:

Bill leaves his desk at work for a meeting as his house broadcasts some data about electricity usage. Bill has locked his desktop computer, so his proxy knows he is not present. It consults his laptop (currently asleep) and calendar, and reasons that he is on his way to a meeting in room B12, due to start in five minutes. Bill has marked sensor data from the house as non-private, so the proxy flashes his name on an LCD screen embedded in the wall outside room B12. Bill soon passes the screen and sees his name; he is slightly early for his meeting, so he stops to press a button and view the data. A passer-by notices, but this is unimportant as the information is not private.

During the meeting, Bill's wife Janet updates her status on Facebook. This is not a high priority item, but as Bill's laptop is open, the proxy flashes up an alert about the update. As no one else is looking at Bill's laptop, he reads this personal information.

Soon after, Bill's boss Abi emails him. Bill's proxy reasons that this may be relevant to the current meeting, but his laptop is now closed. The proxy sends a high priority SMS to his phone,

which vibrates. Bill reads the SMS, which displays the subject line of Abi's email: it is not about the current meeting, so he ignores this for now.

The current prototype cannot fully support this functionality: six changes are required to enable the scenario outlined above. The below list explains these changes and how and where the functionality would be implemented:

1. **Proxies may access computers associated with an end user, in order to find out whether the user is active at a computer.**

   If location is unknown and the recipient is not at an event, check any computers associated with them to see if a computer is active (with this user logged in). If so, send message to the computer, if not, test whether the person may be en route to a location instead (see below). Implemented in `Proxy.sendMessage`.

   Build a 'Device' class. Each device has a URI, such that the Proxy class can ping that URI for a response (and find out when the device was last active).

2. **Proxies need awareness of messages' sensitivity and whether output devices are public (e.g. a communal LCD in a corridor is public; a mobile phone is not).**

   Augment the `DataSource` class with a 'private' Boolean. As default this is 'true' and any message from that topic is private. If a user marks a topic as 'public', then incoming messages on that topic may be received on public devices as well as private ones.

   Augment the `Device` class with a 'public' Boolean, which marks whether it is publicly viewable. By default, devices at a location are public, and on a person are private.

   Edit the `Proxy.SendMessage` method such that when a suitable available device is found, it is only used if the privacy of the device and the privacy of the message match (that is, it is not a private message and a public device).

3. **Allow a person's subscriptions and messages to be marked as 'high priority'.**

Build a `Subscription` class, which holds the URI of the topic in question and also a Boolean. If the Boolean is true, all items the subscription is high priority. The `Proxy.subscriptions` Vector will hold instances of this class, instead of the URIs of topics.

Augment `Message` class with a Boolean. If it is true, the message is high priority.

Edit the `Proxy.sendMessage` logic such that high priority messages are (if possible) sent to devices which means they will be seen sooner (e.g. mobile phone, not email inbox).

Edit the `Device` class such that a device can be marked as suitable for high priority messages or not. (Default setting is 'not suitable'.)

4. **Proxies are aware of the relevance of events to non-attendees (e.g. reasoning that Bill's boss is connected with his current meeting)**

   Augment event and data source information with 'content' tags, in a Vector: these are keywords to do with the event or topic (e.g. 'healthcare', 'project x' or 'social').

   Edit the `Proxy.sendMessage` logic such that if a message is received during an event, the message is treated as high priority when the keywords associated with the event and the message's topic match.

5. **Proxies reason that just before or after an event, an attendee is likely to be in transit to or from that event.**

   Edit the `Proxy.sendMessage` logic such that if the person's location is unknown and we are within five minutes of the start of end of an event, they are in transit to or from this event, and devices near the event may be of use. (Also change the `World.Time` field from an `Integer` to `Time`, reducing the granularity of time from hours to minutes).

   Augment locations with a Vector called `nearByLocations`: this holds a list of locations adjacent to this one. If a device is public (at a location), then ensure that when a message arrives, it behaves as described.

6. **Allow output devices to notify a subscriber of message receipt, only displaying the message content when prompted by the recipient.**

   If a device is public (at a location rather than on a person), then ensure it behaves appropriately on message arrival (logic in the `Device.messageArrived` method).

In summary, two types of change are required to incorporate the above functionality. Firstly, the `Proxy.sendMessage` method, the reasoning engine of the system, needs to handle the more complex logic. Secondly, the classes which represent objects in the world need to be edited or augmented in some way. For example, the Message class requires a Boolean about priority and the Location class needs a Vector listing adjacent locations. It is necessary to build new classes, for example to represent Devices and Subscriptions, but these are already represented in the current system as Strings, rather than more complex objects (note that including a Microprinter device, mentioned in Section 4.4.1, would simply require an addition to the existing Device representations). None of these required changes impact the framework of the system: the changes affect only the complexity of existing logic (in the `sendMessage` method) and objects within the model.

Enhancements towards the envisioned system of Section 4.2 are generally straightforward: for example, enabling user authentication and browsing or searching for subscriptions is simply a matter of building a suitable interface. Including detail about time, people and events in preference lists and enabling 'trusted contacts' involves simply increasing the sophistication of the `PrefList` and `Proxy` classes; similarly, enabling preferences for environments and events involves no fundamental change to the framework.

From the above, it can be concluded that the existing prototype provides a complete and adequate architecture for the envisioned messaging system, and currently uses a simple world model and reasoning. It can be built upon to create a pervasive infrastructure with a social fabric, allowing the easy integration of pervasive social tools.

5 Conclusions and Future work: Systematic Use of Methodologies to Understand Online Social Phenomena

This report has discussed how pervasive technologies might be used as a base for building a widely-available social fabric. The multimodal messaging infrastructure is effectively the underlying framework that will support the fabric, routing and transforming messages. The social fabric, by contrast, comprises the interface and social model supported by this multimodal framework.

This section describes the research question, expected contributions and plan of action.

5.1 Research Question

The research question is: Can a systematic framework of methodologies be developed to understand the motivations for and experiences of social web-based phenomena, in order to re-imagine these phenomena in novel contexts?

Parts of this question can be explored further:

Methodologies refers to various methodologies from non-computing domains, such as HCI (Experience Deconstruction) and social theory (Actor-Network Theory). These methodologies grant different and diverse perspectives on matters, perhaps providing holistic or ludic insights.

A systematic framework of methodologies refers to understanding, ordering and applying the multiple methodologies in such a way as to maximise their strengths and minimise their weaknesses, ensuring that they are used as effectively as possible, in a manner which is complementary.

Social web-based phenomena refers to web-based interactions which commonly occur on social networking websites. Social networking websites are websites geared to augmenting personal friendships and communication, rather then facilitating work-oriented matters. An interaction can be considered to commonly occur on these sites if it appears on more than one major social site.

The act of **re-imagining** refers to re-interpreting an experience or interaction. This involves recreating it such that it appears different to the original experience (i.e. it is presented in a different fashion), but maintains the same underlying motivations and experiences associated with that original experience.

Novel contexts particularly refer to making the phenomena more manifest in the pervasive world, in a fashion which may be ludic and novel.

5.2 Description and Contributions

Contributions the author expects to make by answering the research question are:

1. Analysing and evaluating methodologies for understanding online social phenomena
2. Building and using a systematic framework for applying these methodologies

3. Re-imagining the social networking experience via pervasive channels

It is hoped that this work will facilitate the re-imagination of social systems in novel or unusual contexts, perhaps in a ludic fashion such as that of digital family portraits (Mynatt, 2001) and table-based devices such as the TeleTable (Donaldson, 2005) and the Drift Table (Gaver 2004). Additionally, it is hoped that as a result of this work, people will be able to use individual methodologies more effectively, and apply the re-imagining framework to experiences from other domains. The re-imagined social networking experience itself may act as a starting point for work on enabling access to social technologies, or investigating the ways in which people use these in different contexts.

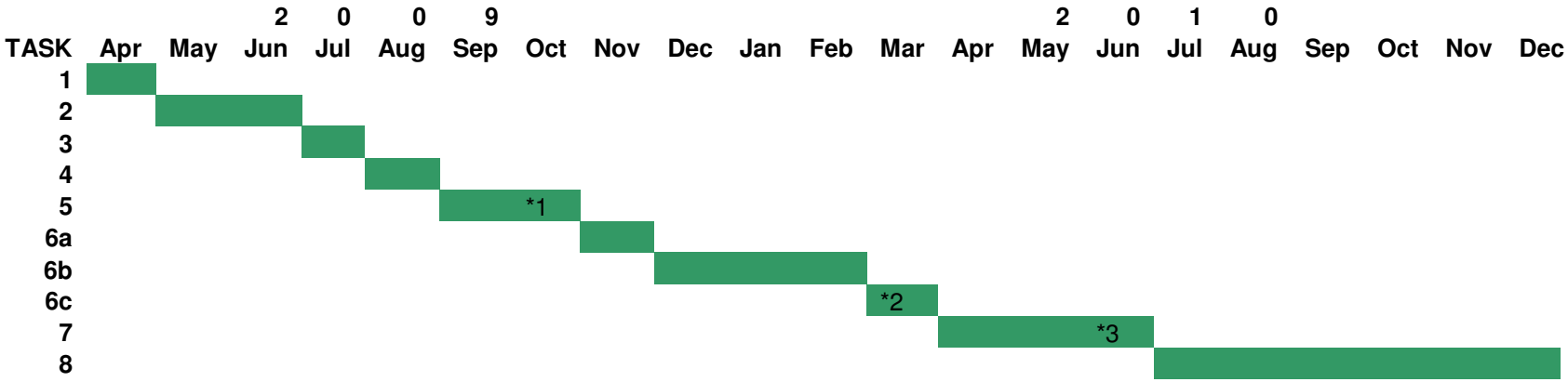
5.3 Time Plan

Table 1, below, presents a Gantt chart showing the ongoing plan. The first contribution (analyse and evaluate methodologies) is provided by tasks 1 – 3. The second contribution (providing the systematic framework for applying the methodologies) is covered by tasks 4 – 5. The final contribution, re-imagining the social networking experience via novel channels, is covered by tasks 6 – 7. Appropriate points to publish material are shown on the Gantt chart.

Note that there are two points where the framework is evaluated: tasks 5 and 7. In task 5, an initial evaluation takes place, considering the effectiveness of the framework for organising methodologies to get new knowledge. Task 7 allows a more in-depth evaluation, which accounts for the system built based on use of the framework during task 5.

Evaluations are key to this work. Methodologies can be evaluated by considering the usefulness and accuracy of information gained by applying them. The framework can be evaluated by considering the knowledge yielded by its application, and the effectiveness of that knowledge in driving the implementation of the social system. The system can be evaluated by applying the framework to it, in order to demonstrate whether it offers an equivalent experience to the original, web-based functionality; another method is to carry out a user evaluation.

Table 3. Gantt chart



1 Survey lit to find and understand appropriate methodologies; also contact people *4
2 Apply methodologies to social experiences; improve understanding of the experiences and the methodologies
3 Analyse and evaluate the methodologies
4 Design approach for systematically applying the methodologies to experiences
5 Apply systematic framework: evaluate new knowledge and the framework itself
6 Use this understanding to build a pervasive social networking system
  6a Design
  6b Implement
  6c Test
7 Apply framework to the system: evaluate system and framework
8 Write up

*1: good point to publish material on the framework: consider WebSci as the venue
*2: good point to publish material on the system
*3: good point to publish an evaluation of the framework and the system
*4: contacts: Cathy Pope, Susan Halford, Alan Dix, Jayne Wallace

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Appendix A: Functionality Provided by Social Sites

This appendix details the primary functionality (as defined in Section 3.3) of various social sites, from data gathered in August 2008.

All sites provide a **profile page**, **friends list**, **news feed** and **private messages**. Table 4 shows further functionality.

Table 4: Primary functionality of selected social sites

	Functionality								
Site	**Photos**	**Groups**	**Public messages**	**Micro-blog**	**Blog**	**Videos**	**Apps**	**Music**	**Events**
Bebo	x	x	x	x	x	x	x	x	
Facebook	x	x	x	x	x		x		x
Friendster	x	x	x	x	x	x	x		
LinkedIn		x		x					
Match	x								
MySpace	x	x	x	x	x	x		x	
Orkut	x	x	x	x		x	x		
Twitter		x	x	x					
Windows Live Spaces	x	x	x		x				x

Some sites included other prominent functionality, listed below:

- **Bebo**: authors, Bebo Nation, to do list
- **Facebook**: birthdays, pokes, instant messaging
- **Friendster**: connections (subtypes: Friends, schools, 'fan of', bookmarks, groups), schoolmates, featured fan profiles
- **LinkedIn**: friends list is called contacts list, Q&A, jobs
- **Match**: winking, favourites, searches
- **Orkut**: testimonials, lists (bookmarks, hot/crush/ignore list)
- **Twitter**: view all recent public Tweets. Note: public messages are provided via the @name convention, and groups via the #groupname convention.
- **Windows Live Spaces:** files, lists (books, music, blog, movies, custom)

Examples of peripheral functionality include:

- **Bebo**: blogs, sayings
- **Facebook**: pokes, birthdays, people you may know

Appendix B: Profile Data Provided by Social Sites

This appendix details, for each site, the information which can be provided in the site's profile. The below data was gathered in August 2008:

All profiles include a **name**, **profile picture**, **location** and some amount of **free text**: sometimes the free text is guided (e.g. lists of favourite things, political or religious views), but not always (e.g. "About me"). There is a link between profiles and functionality: for example, a person's profile is linked with that person's list of friends. Similarly, profiles link with other functionality, such as photos, groups, and videos. Table 5 shows further options available in profiles:

Table 5: Profile breakdown of selected social sites

	Fields for information on...					
Site	**Education / work**	**Age**	**Gender**	**Relationship info**	**URL**	**Contact info**
Bebo	x	x	x	x		x
Facebook	x	x	x	x	x	x
Friendster	x	x	x	x	x	
LinkedIn	x				x	
Match	x	x	x	x		
MySpace	x	x	x	x		
Orkut	x	x	x	x	x	x
Twitter					x	
Windows Live Spaces	x	x	x	x		

In addition to the above material, some profiles allowed for further information, listed below:

- **LinkedIn**: specialties
- **Match** gender/age/location of interest, physical features (height, body type, eye colour, hair colour, body art, best feature), star sign, and many more details
- **MySpace**, star sign, ethnicity, whether the user smokes or drinks
- **Orkut**: fans
- **Windows Live Spaces:** nickname, pets