Sentient Computing meets Social Networking

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1 Introduction

Sentient computing was conceived in 1999 and aims to make applications more responsive and useful by observing and reacting to the physical world [7]. It is particularly attractive in a world of mobile users and computers. In recent years we have observed a convergence between services enabled by ubiquitous computing technologies [16] and applications offered to social networks. The overlap will continue to increase as 'web-friendly' handsets flood the market and sensors becomes more commonplace. There has been work published on the social implications of ubiquitous computing [5], but as the technologies spread out of laboratories and into real-life settings we believe their potential benefit to social networking is worthy of further consideration. Our aim in this position paper is to identify this intersection as a fruitful topic for discussion, provide references to a few examples of relevant research and offer thoughts on lessons learnt and challenges for the future.

2 Systems and sensors

Location sensitive services may be facilitated and brought to the fore through the integration of positioning systems such as GPS and cellular triangulation into handheld devices. This has enabled a new class of social applications focussed on local interactions with other users and the environment.

An active field of research over the past two decades has been indoor positioning systems, which aim to locate users within buildings where GPS fixes are impossible. These can complement existing outdoor mechanisms to provide a richer source of context information: in particular, they allow more to be inferred about the activity of a user.

One of the earliest examples was the infrared based Active Badge [15]. Subsequent developments included the ultrasonic Bat system in our laboratory [1], which offers very fine grained location information at the cost of a large infrastructure investment. A fuller discussion of the multitude of research systems is beyond the scope of this paper, but Hightower and Borriello provide a good survey of the field [6].

The requirements for expensive infrastructure and bespoke electronics have so far confined these systems to research laboratories, but more recent technologies such as Bluetooth [3] and WiFi [2] positioning repurpose existing infrastruc-

ture and promise indoor location using today's consumer devices. Data from multiple sources can be aggregated to provide more accurate or more robust estimates [9, 13]. Alongside a map distribution mechanism, this could allow global positioning and location awareness. The same infrastructure can be used both to infer and to distribute context information.

In tandem, the advent of microelectromechanical systems (MEMS) technology has resulted in the miniaturisation of sensors such as accelerometers, magnetometers and gyroscopes and a dramatic drop in cost, allowing them to be integrated into consumer gadgets for the first time. These, too, have the potential to provide a wealth of data to inform social networks.

The papers cited are merely examples of a broad range of work, and the techniques mentioned are already starting to be incorporated into production devices. How might social applications take advantage of these new opportunities?

3 Location-based services

The research literature contains numerous examples that demonstrate the potential of these technologies in wider social networking contexts. One application that is often touted is a 'colleague radar' akin to Harry Potter's 'Marauder's Map' which shows at a glance the locations of coworkers within a building. Examples include the ACTIVEMAP tool [10] and the 'intelligent Coffee Corner' [12]. These have been represented in a variety of forms: the visual similarity between an Active Badge application displaying a simple list of people and locations and a modern RSS feed of friend status is notable, and 3D representations of the data resemble metaverses such as Second Life. Location systems provide a way to bridge the physical/digital divide [8].

A further application that raises interesting social questions is the 'interaction diary' that 'automatically populates a Google calendar with persons encountered and meetings attended' [4].

All of these were developed as proofs of concept or research tools, but their aims and functionality bear resemblance to a wave of recent location-sensitive social networking applications such as Brightkite[1], Rummble[2] and Google's dodgeball service[3]. They represent the tip of the iceberg: imagine the applications that could be created if social interaction were a design goal rather than a happy coincidence. The key change going forward is one of granularity: the existing web-based services operate at the scale of city blocks, while the research systems refer to individual rooms. Clearly, with increased resolution comes increased potential reward but also magnified privacy risks and concerns.

4 Context-aware applications

Context-awareness can be thought of as a layer constructed on top of sensor systems that allows applications to adapt their behaviour to a user's status and activity. Today's social networking applications are generally based on the

[1] `http://brightkite.com/`
[2] `http://www.rummble.com/`
[3] `http://www.dodgeball.com/`

premise that the user will input his or her own data manually — the notion of human beings as sensors. Tomorrow's will be able to draw on a plethora of sources to infer a richer basis for interaction. Location systems are a key data provider, but not the only one: the latest generation of mobile phones also contain, amongst others, light, temperature and proximity sensors, all of which can play a part.

To offer a few examples, one researcher in our group sets his Facebook status automatically based on context information derived from the Bat system. Sentences like "Joseph Newman is getting up from his computer" can be inferred from knowledge of the spatial containment before and after the event. Similarly, Andy Stanford-Clark at IBM has pioneered 'tweetjects': physical objects that can communicate via Twitter[4]. These provide updates such as "unusually high electricity use" and "bathroom heater turned on", and can help inform decisions to reduce energy consumption. Communities have formed around power graphs, sharing advice and experiences. The CenceMe application provides a good example of a mobile application that allows the sharing of context information inferred through sensors via social networks [11]. This includes not only location but also activity: it can detect 'dancing' through the accelerometers, for instance, or 'conversation' through the microphone.

Inferring context has proved to be a difficult problem, and research is still ongoing. Although the quality of the underlying sensor data is crucial, more fine grained data does not necessarily lead to better end results: often it tends to induce more fine grained predictions which are accordingly more often incorrect. For example, attempts to detect when meetings were happening based on people in proximity for some period of time proved problematic: how do you distinguish between two people looking for the milk and two people discussing a project? Building trust in dependable systems seems vital to increase adoption.

5 Privacy

Some of the news headlines that came out of the Active Badge system include: 'big brother pinned to your chest,' 'Orwellian dream come true, a badge that pinpoints you,' and 'badges monitor staff.' This sociological reaction around location-tracking and privacy has rarely been taken seriously by the research community [14]. An example of key questions to be addressed is the 'outside-in vs inside-out' debate – that is, whether devices should determine their own positions autonomously and therefore be the sole guardians of private information or rely on external infrastructure to assist them and exchange privacy for convenience and battery life.

Consideration should also be given to the trust model for data sharing. The Bat system provides a notification service whereby a 'watch' can be set on a particular user. The principle of *reciprocity* demands that notifications are symmetrical: i.e. if A sets a watch on B, B would also be notified of this fact. Other social networks, such as Dopplr[5], permit one-way sharing of data: A may share his trips with B, but B may not necessarily share his with A.

Many social networking sites have developed thoughtful and considerate mechanisms for managing the tradeoff between utility and privacy — but these

[4] `http://twitter.com/andy_house`
[5] `http://www.dopplr.com`

will require adaptation to cope with more fine grained data. Work is underway on mechanisms for minimising the amount of information that must be revealed to benefit from new applications, but balancing cost against benefit and gaining the trust of the population require more than technical breakthroughs. Location systems can no longer be developed in a vacuum: attention must be paid to their ultimate uses and end users' perception of their capabilities.

6 Conclusions and challenges

It is our belief that context sensitivity is sufficiently mature to break into social networking and have a significant impact on the way we interact with friends, families and coworkers. Numerous attempts have been made at sentient systems, some of which have enjoyed considerable success in real use and some of which have faded away. Privacy and interface design clearly pay a key part in determining their fate, and future work on social networking might be informed by these projects to learn from their experiences and mistakes. Similarly, the research field should look to the efforts of social application developers to see how their technologies might be deployed successfully on a global scale. Many of the same challenges are faced in both fields: promoting adoption, maintenance difficulties and diminishing returns. We hope that further crossover, interaction and debate will prove beneficial to the state of the art.

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