MAKING USE OF SERENDIPITY: A NEW DIRECTION FOR PERVASIVE COMPUTING FROM A SOCIOLOGICAL VIEW

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Abstract
Everyday, a person can have numerous opportunities to connect with strangers or acquaintances around him/her. In this paper, we demonstrate how pervasive computing can help a person connect with others by initiating communication, and how (s)he can take advantage of these connections. We envision a future mobile information space (called the MobiSpace) that is constructed based on ad hoc collaborative networks, where nodes in these networks are capable of broadcasting messages using wireless medium. From a sociological perspective, we investigate relevant theories in the fields of sociology and social psychology. We discuss how these theories can help us formulate new mobile applications for social interaction and collaboration. Integrating these theories, we propose the SUIC model (Self Presentation-Uncertainty Reduction-Information Dissemination-Collaboration) for future mobile application development. In addition, we discuss what challenges new applications bring to the underlying system. Our work pioneers the application of pervasive computing to social interaction and initiation, and provides the research community a new direction for further mobile application development.

1. Introduction

A mobile device is not just an extension of a desktop computer. Given the extremely high penetration rate of mobile devices (PDAs, cellphones, etc.), and the fact that users carry their mobile devices with them anytime, anywhere, a mobile device has become an extension of the person who holds it. These devices are in a perfect position to foster existing interactions and create opportunities for new social interactions, provided that the software in these devices and the infrastructure behind them are designed to support these activities.

Imagine a simplified situation depicted in Figure 1. James, Ed, and Sophie happened to be passing by the City Hall. These four entities (three people and the City Hall) in the space are equipped with short-range wireless transmission technologies and an appropriate software infrastructure, enabling them to broadcast messages to other entities in their proximity. The range of an entity's broadcasting forms the sphere of a "**MyAura**", which is used to denote the messaging medium via which the entity sends/receives messages. We can then construct a mobile information space (we call it the **MobiSpace**) in the physical space with each entity's MyAura.

The MobiSpace is a virtual space where every entity can express him/herself by broadcasting whatever information (s)he wants others to know, and information flows among entities with the help of mobile collaborative networks. Within MobiSpace, location-based information systems can be viewed as

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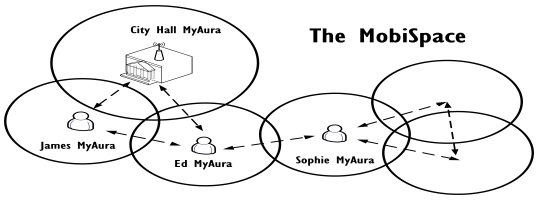


Figure 1. The MobiSpace constructed by MyAura of entities in the physical space

special cases in the above model of entities interaction. For example, in Figure 1, a location-based information system allows the City Hall to express itself with messages saying what the upcoming events are, providing a link to the history of the City Hall, etc. There are many such prototyped testbeds, like the GeoNotes [5] and ActiveCampus [6] projects.

Links between James and Ed, and Ed and Sophie in Figure 1, however, are paid little attention. These are the links that we constantly have chances to establish in our daily lives. Having your coffee in a cafe, walking in a shopping mall, and waiting in a line buying tickets, are all opportunities to meet new people. Our axiom here is that people are willing to interact socially. When their "MyAura" contact, these links can thus be established and utilized to help users achieve their goals. It is our intention to stimulate new social interaction paradigms or applications of pervasive computing. The central question we address in this paper is:

What pervasive computing applications can utilize a person's MyAura and his/her everyday serendipitous meetings with others?

The question can be answered by understanding how social interactions are performed and what the relationships are among people. We discuss three relevant sociological theories: (1) the Presentation of Self, (2) the Strength of Weak Ties and (3) the Uncertainty Reduction Theory. These theories correspond to three issues in our everyday social interaction activities: (1) what to show to others (2) how to relate to others and (3) what to feel about others. Based on these understanding, we explore how pervasive computing applications can assist or augment our social interactions, and how we can utilize these interactions to achieve our tasks. Integrating these findings and results, we propose the **SUIC** (*S*elf Presentation-*U*ncertainty Reduction-*I*nformation Dissemination-*C*ollaboration) model for future design and development for pervasive computing.

This paper is structured as follows. In the next three sections, we discuss major theories and their implication on new mobile application design. We describes the proposed SUIC model that integrates former findings and results in Section 5. We conclude with implementation issues and future work in Section 6.

2. Presentation of Self

When we interact with others socially, we are more or less presenting our "selves" to others with verbal/non-verbal communications. From the social psychological point of view, the "self" of a person is composed of two parts: the *"inner self"* and the *"public self"*. This distinction has been made by researchers such as Cooley [4] and Mead [10]. The inner self is one's own understanding of who (s)he is. This understanding can be projected and transformed into expressions and presentations, namely, the public selves, of the individual. Public selves are what are perceived by others, and their function

is to convey information about the individual.

One implication of this idea is that what people present and convey to others can be different from the inner self, the personal understanding of self. The decision of what to present goes through a complicated structure that incorporates factors including experiences, social norms, expectation and goals, the context of social interaction, etc. Based on these factors, we determine how to present ourselves under certain interaction context such as the location, the occasion, and the type of people with whom to interact. In addition, our presentation (i.e. our "public selves") may change according to our understanding of the perceptions others get during the interaction. According to Goffman's "dramaturgical viewpoint" [7], social interaction is a performance. Communication becomes a series of performance. We alter the role we play (i.e., switching among different public selves) during the communication based on what is acceptable or pleasant and the feedback from others.

"MyAura" serves as an additional natural channel to convey the "public selves" of mobile users. Everyday when we choose our clothes and shoes, hair style, bags, ring-tone and cover of our cellphones, we are showing different aspects of our public selves by changing the outfit. Similarly, we can use MyAura to broadcast our "digital outfit". Here is an example how MyAura can be used as presentation of selves:

Participants of Pervasive 2004 are using MyAura to broadcast their "digital outfit" with professional information including name, affiliation, contact information, and research interests. One can quickly view these information with his/her PDA, and do content/interests searching and matching. Ed, first time in Vienna, is looking for people to hang out with when today's program ends. He uses MyAura to broadcast this intention along with his photos and personal interests. As he walks around the convention center, he is prompted with a message saying that James, who also attends the conference alone, is interested in clubbing. Ed clicks the icon representing James on the map, and gets James's personal web pages sent out by James' MyAura. He learns that James is finding someone to share the hotel double room, so he replies to James. They meet and have a great chat. At night, James and Ed changed into stylish outfits and go to a bar for fun. Their PDAs switch their "digital outfit" from professional to casual one saying (by broadcasting via their MyAura) that they are first-time visitors to Vienna, and are looking for interesting places to go and people to chat with.

In the above example, the system should allow mobile users to switch among different public selves easily and sometimes purposely to facilitate the "role-playing" in the daily "performance". Context-awareness and intelligence of mobile devices can be used to automate the switching. We note that a public self can be of a variety of forms. It can be a photo, a personal web page, an paragraph of personal diary, an avatar with facial expression, etc.

3. The Strength of Weak Ties

We all have our own interpersonal network, where the nodes in the network denote people and the link (or the "tie") between each pair of nodes represents that the two people "know" each other. The "knowing" could be strong or weak; we have very close friends and family members while we also have relatives who are living on the opposite side of the globe. The seminal paper "The Strength of Weak Ties" by Granovetter entitled argued the cohesive power of weak ties in the diffusion of influence and information, mobility opportunity, and community organization [8]. His analysis of interpersonal ties suggests that if we would like to spread information, weak ties will work better as the diffusion channel than strong ties. Consider the case of spreading a rumor [8]. If one tells a rumor

to his/her close friends, the rumor will probably be moving around a few small groups and "trapped" without spreading outside these groups, because there is a good chance that those strongly tied share nodes (friends).

We argue that in the MobiSpace, as users moving around with their mobile devices, mobility of users can help to create opportunities of establishing new "weak ties". These ties serve a good channel for information dissemination. Some scenarios are:

- *James, the singer of a jazz band, will have his debut performance three weeks later. He wants this information to reach as many people as possible in the campus and record company people.*
- *Patti, an entrepreneur with a business plan focusing on educational electronic toys, is using MyAura to ask for information of educational toys manufactures in the local area and also look for possible collaborators with expertise on developmental psychology and EECS (the system will do the matching for her). She also uses MyAura to find fans of the New York Voices to go to the live performance together.*

In the above scenarios, the provision of mobile devices and MyAura enables people to diffuse information and questions as their "MyAura" makes contact with others in their proximity. Weak ties connect people of different cliques/groups, and thus help the spreading of information by transmitting across the group boundaries. People can leverage their mobility and utilize the opportunities of contacting co-located people to help each other, and possibly, construct communities with these newly created weak ties.

4. Uncertainty Reduction Theory

Uncertainty Reduction Theory (URT, [3]) is a major approach to impression formation and initial relational development in Face-to-Face (FtF) settings. People collect information to predict others' attitudes and behaviors in order to reduce the uncertainty of interaction. They can then create impressions/mental models of others in the process of uncertainty reduction. According to URT, individuals could use *passive*, *active*, and *interactive* strategies as means of uncertainty reduction:

1. **Passive strategies:** observing the target unobtrusively in situations in which the target communicates with others.
2. **Active strategies:** asking others who know the target person, or manipulating the environment, creating a set of situations that the target's behavior can be observed unobtrusively.
3. **Interactive strategies:** asking the target questions directly, attempting to detect target's deceptions, or performing self-disclosure to the target.

One direction of application research could be using mobile devices and context-awareness to assist users while using strategies above or augment/enhance the uncertainty reduction experiences:

- *Analyze the mobility of a target and identify the Living Zone of a person (e.g., 85% of time she moves around the Fifth Avenue, etc.) and based on that, identify possible matches among people*

or providing social cues for interaction initiators to reduce uncertainty. Create visualization of these co-located people's social activities, current emotional, available status, or exciting personal experiences (e.g., "I have climbed Mount Everest) to further reduce the uncertainty of interaction.

- *Devise new ways of interactions between people. Imagine the case that Emily, sitting in a cafe, uses MyAura to deliver a questionnaire to anyone who is trying to initiate communication with her. The responses to the questionnaire are used to figure out the attractiveness of the correspondent.*

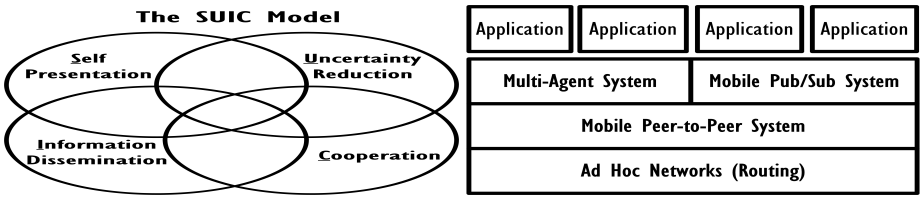
Since mobile devices carry a wealth of personal information such as calendar, the current location and past mobility history, buddy list, address book, sensory information, etc., social cues can be derived from this rich source of context information, the they can be used to initiate or enhance possible interactions. This is a field that is not getting addressed in the present literature, while research in areas such as "Affective Computing [1]" and "Sociable Media [12]" have extended our knowledge of relationship between emotion and computing, and media that foster social activities. We believe that by understanding the interaction initiation and relational development from a sociology perspective, the research community can come up with more innovative mobile applications.

5. The SUIC Model

The SUIC model (Self Presentation-Uncertainty Reduction-Information Dissemination-Collaboration) is the integration of our understanding of mobile applications for ad hoc collaboration and social interaction. Figure 2-(a) shows the chart of the four major domains. Three of them are what we discussed in previous sections, while the collaboration domain has been extensively explored by the Computer Supported Collaborative Work (CSCW) community. During the study of these theories and applications, we found that most applications can provide more than one social feature. For example, when you initiate a communication with a person by sending your digital outfit using MyAura, you are reducing both you and his/her uncertainty and presenting your self at the same time. Another example could be a mobile ad hoc polling. You pass out votes to people that are around you (collaboration), and they will forward the votes using their contact list or their MyAura (Information Dissemination) to reach more voters. This SUIC model provides the research community a starting point to design innovative mobile applications for social interaction and collaboration. A point worth noting is the difference between traditional Computer-Mediated-Communication (CMC) and Mobile-Computer-Mediated-Communication (m-CMC). The communication in CMC is purely virtual during the communication, while the m-CMC we discussed in this paper is acting as a catalyst that fosters physical communication (FtF).

6. Conclusion and Future Investigation

In this paper, we propose the idea of using MyAura and location-based service to construct a Mobile Information Space, the MobiSpace. We examine several seminal social psychological theories to stimulate the Pervasive Computing research community to develop innovative mobile applications for social interaction. We successfully identify several applications domains that have not been discussed previously. By identifying system requirements and architecture to build these applications, we hope to provide a generic platform for most applications in social interaction based on ad hoc collaborative networks. Our proposed system architecture is depicted in Figure 2-(b). A mobile peer-to-peer system



(a) The SUIC model for pervasive social computing applications

(b) Proposed architecture for MyAura and the MobiSpace

Figure 2. The SUIC model and proposed MyAura architecture

serves as a middleware that allows entities in the MobiSpace to interact in a decentralized manner. We utilize a mobile publish and subscribe (Pub/Sub) system and multi-agent system to intelligently manage and process the messages each MyAura broadcasts in the space. It is worth noting that building up MyAura applications calls for additional system requirements. For example, the system should transmit the messages with considerations such as the content of these messages, how many hops and how long they can travel, etc. In addition, we need to design a mechanism to process and utilize context information (e.g., location, schedule, etc.) in order to support the applications and the multi-agent or mobile pub/sub systems. Previous systems, including Proem [11], iCloud [9], Agent-based middleware [2] and alike, have utilized spontaneously co-located groups for sppecific information sharing. However, they are not geared toward supporting social interaction and broader applications. Further user testing will be conducted to evaluate the effectiveness of the identified applications under different scenario settings.

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