Urban Enclave Location-Aware Social Computing

Quentin Jones, Cristian Borcea, Starr Roxanne Hiltz, Brian Amento,* and Constantine Manikopoulos

New Jersey Institute of Technology

**Also AT&T Labs Research*

Urban enclaves have richly interconnected social and physical geographies, much of which is hidden from casual observation. As a result, interpersonal collaboration, coordination, and socio-physical navigation is often suboptimal. We are exploring how ubiquitous social computing applications that seamlessly provide location-aware information about people and places could help address this situation. As part of this effort, we are turning an urban university campus into a living laboratory for systems that link people-to-people-to-place. This allows us to examine human centered computing challenges, such as effective privacy management and social recommendation system design, through use of a suite of applications glued together by a unified middleware layer that leverages an increasingly rich model of an enclave's people and places.

Keywords
Ubiquitous Computing, Social Software, Computer Supported Cooperative Work, Mobile Computing, and P3-Systems

Today, we are confronted by a world with global environmental challenges, lots of technology enabled angry men, and radically differing conceptions of human rights in different corners of the world. Such a world calls for a human centered computing that recognizes the potential of ubiquitous social computing cyberinfrastructure to improve social capital formation and maintenance through designed 'emergence'. In other words, human centered computing researchers need to explore how small, computerized actions of many individuals, both in virtual and physical environments, can be structured and leveraged to improve societal functioning. Achieving such human centered computing goals requires significant advances in our understanding of social dynamics and social psychology, so that systems built can leverage user's actions to meet both individual and community needs. This requires a focus on issues that only become relevant when applications are used by a community of users (e.g. privacy management in pervasive computing environments), or enabled by analysis of a data generated by a large number of users (e.g. social recommendation systems). It also means an expansion in the scale of applications research, so that potential links between software design and social impacts are explored. It is within this conceptual environment that we are exploring urban enclave location-aware computing through our *SmartCampus* initiative.

Cities are rich environments comprised of various landscapes, districts and places. One common feature of the city is the "urban enclave," which is an identifiable physical area, containing multiple buildings or venues associated with a specific neighborhood organization, purpose and/or community. The urban enclaves we are interested in are typically utilized on a daily basis by between 1,000 and 20,000 individuals, consisting of a permanent to semi-permanent core of members and a regular flow of visitors. As a result, they have considerable changes in population over time. Enclaves contain some areas open to the public and others locked and protected for "members only." Examples could include a China Town, a corporate office or a large museum complex with associated eating and shopping spaces, or a college campus in a downtown urban location. We are exploring how to use our growing ability to seamlessly locate individuals as they go about their everyday activities in urban enclaves to improve communication, coordination and social connectivity, through systems that link **P**eople-to-**P**eople-to-**P**laces, or P3-Systems [6].

While urban enclaves often provide a good environment for people to come together, their very nature suggests why improvements in social connectivity and coordination, enabled by P3-Systems are desirable. First, invariably, along with the large number of individuals who come and go in urban enclaves, community members routinely miss opportunities to leverage inter-personal affinities (such as shared interests and backgrounds) for friendship, learning, or business through simple lack of awareness. This lack of awareness of relevant affinities might be between individuals who know each other, familiar strangers [9] that see each other at the enclave but do not know each other, or complete strangers in physical proximity. Secondly, the geographical spread of many enclaves creates coordination problems. For example, individuals may find it hard to bring a dispersed group together, or fail to realize that somebody is in the vicinity for a meeting. Thirdly, improvements in social connectivity and coordination are likely to be of significant value to enclave community activists and members. For example, administrators of urban campuses may see increased effective communication between students, faculty, staff and visitors as beneficial to campus life.

If we are to use P3-Systems to routinely help tie together the overall social fabric of enclaves, we must overcome a number of major challenges to effective large-scale deployment, including:

1) Developing mechanisms for the dynamic identification of ‘places’, both for individuals and groups, that form in any urban environment, which are key to enabling context-aware services;
2) Using data from heterogeneous devices and systems to create relevant personal, group and community geotemporal profiles;
3) Designing middleware that over time builds a rich world model that allows for the collection and effective sharing of personal geotemporal data between various P3-System applications deployed in an enclave environment.
4) Developing user interfaces and interaction techniques that enable valuable services while respecting user privacy.

We are exploring each of these challenges through our *SmartCampus* initiative.

In the sections that follow, we describe important trends in social software and ubiquitous computing and describe how the merging of the two fields will enable the collection and generation of data that can be used by P3-Systems and associated enclave middleware to enable next generation social connectivity.

Leveraging Emerging Ubiquitous Computing Infrastructure and Social Software Paradigms

Until recently, ubiquitous computing research has focused on either the development of supporting technical infrastructure (e.g. wireless networking, mobile devices, etc.) or one of three application-driven human computer interaction (HCI) themes [1], i.e., 1) natural interfaces, 2) context-aware applications, and 3) automated capture and access. Recently, a fourth HCI research theme has come to the fore, the design of computer supported collaborative work (CSCW) or community systems, aided by ubiquitous computing infrastructure. Much of this work has been on systems that specifically utilize location to link **P**eople-to-**P**eople-to-**P**laces (P3-systems). The increasing importance of this fourth HCI theme is the result of advances over the past 15 years in mobile computing infrastructure. Increasingly, everyday environments are populated by individuals with mobile, location-aware, always-connected computing devices. This changing technological environment has inspired a growing number of researchers to focus on the design of social software enabled by ubiquitous computing infrastructure.

The term ‘social software’, is a relatively recent but increasingly popular label for software that enables computer-mediated communication, collaboration and coordination that may lead to the formation of computer-supported social networks or communities. Popular examples of social software in rough historical order include: computer bulletin boards, email, email lists, Internet Relay Chat, instant messaging, and of more recent popularity, Blogs, Wikis, friend-of-friend systems or social network services, and social tagging applications. P3-Systems are also social software.

The most recent trend in social software, deriving the key system value propositions from presenting to users the "emergent outcomes" of the accumulated actions of a community of system users. This approach is highlighted by popular deployments of social-networking applications (e.g. Friendsters.com, Linkedin and Orkut,), and social tagging applications (e.g. CiteUlike, del.icio.us, and flickr). To clarify this "emergent outcomes" approach to social software, and its connection to the deployment of location-aware community systems, we will describe how the two types of social software systems of direct relevance to our work derive their value propositions; these are social networking and social tagging applications.

The typical way in which social-networking applications derive value is by allowing users to profile themselves and store and share information about their social connections to others. This data is then leveraged to enable a variety of services, such as finding experts or social matching, which in turn encourages further system use and adoption. As urban enclave social computing should support expertise finding and social matching, it makes sense to develop P3-System social networking applications that are extended by enabling users to create and share geotemporal profiles.

Social tagging applications build services around users adding freely chosen keywords/labels/tags to content. This metadata is utilized to improve content searches and for visualizations of trends and associations, often in the form of the most common tags and associated content being preferentially presented back to users to create a positive feedback loop. Users of social tagging systems derive value in a number of ways including quality tools for storing and sharing content. More strikingly, value is usually derived from emergent system properties such as knowledge discovery and improved social connectivity through the folksonomies (tagging derived taxonomies) developed. Crucially, this approach systematically encourages the authorship of large-scale semantically rich metadata and its self-organization to enable smooth navigation of user content.

In summary, by combining emerging ubiquitous computing infrastructure, which enables any-time, any-where location awareness and communication, with new social software paradigms that offer value and motivate users to provide meta data, we can now collect, through appropriate middleware, the data necessary for the creation of rich computerized models of physical and social geographies, and the connections between them. With the development of such dynamic 'world models,' it should be possible to enable services that improve social connectivity and coordination within community enclaves. While various location-aware community system applications have been developed and deployed (e.g. [2,8]), we believe our cyberinfrastructure which is specifically designed to support P3-systems with emergent properties, linked to a unified middleware layer and 'world model' which increases in realism and complexity with time, is unique.

P3-System Design Space

The P3-Systems framework describes the design space of location-aware community systems by categorizing approaches into eight basic design techniques. We use the term design technique because a single P3-System application can provide multiple user interfaces and services, and utilize various geotemporal social models associated with each of the aspects of the overall design space described below. These eight techniques have been identified through a systematic analysis of P3-Systems prototyped to date and associated research, and are outlined by a presentation of the P3-Systems conceptual framework [5,6].

As shown in Table 1, the framework organizes the design space of location-aware 'community' systems into a 2 x 2 matrix of different type of system techniques. The rows of the framework distinguish between four different approaches to 'situating' the interaction environment with regards to physical space (spatial foci). We divide these into two:

- *People-centered* techniques where the focal point is either 1) the users geographic location, or 2) the users relative location to other people and objects in the environment.
- *Place-centered* techniques where the focal point is either 1) on user activities in a particular physical location, or 2) online interpersonal interaction in spaces that match/represent physical location.

The columns in the framework divide communication and location aware design techniques into synchronous and asynchronous approaches. This distinguishes techniques that provide information about current user location or activity within a place from those that provide historical information.

Table 1. P3-System Framework Techniques Summary and Representative Information Services

Design Techniques		Synchronous Communication or Location Awareness	Asynchronous Communication or Location Awareness
People-centered	**Absolute user location**	1. Uses awareness of current user locations **P3 Information Service Example** Where is approved buddy X now?	2. Uses people's location histories **P3 Information Service Example** Where has approved buddy Y been?
	Co-location / proximity	3. Uses real-time user co-location **P3 Information Service Examples** Who is nearby? Is there anybody around whom I might like to meet?	4. Uses co-location history to exchange social information **P3 Information Service Examples** When did I last meet X? Who has routines like me?
Place-centered	**Use of physical places**	5. Uses online representation of user's current use of physical spaces **P3 Information Service Examples** How crowded is this place now? What music is playing is this place? Is anyone in this place now that might help with a place-based task, e.g., get me a coffee?	6. Uses history of people's use of a particular space **P3 Information Service Examples** Does this place tend to be busy at specific times? What music is typically listened to here? Do people like me use this place?
	Matching virtual places	7. Uses synchronous online interaction spaces related to physical location **P3 Information Service Example** How do people describe the activities happening here now?	8. Uses asynchronous online places interactions related to physical location **P3 Information Service Example** What have people said about activities that occur here or services offered?

P3-System applications, while often providing multiple information services, have nearly always been independently developed and deployed. Consequently, each new application has also routinely been associated with the development of completely new models of individual users, social networks and places. This approach not only slows software development, but also reduces the potential quality of user experience. This is because ideally the intelligence / sophistication of such models should increase with time as environmental monitoring results in more detailed profiling. For example, while system builders might be able to leverage existing maps, and even some location linked content, a rich urban environment my contain multiple places with quite different social practices, occupancy patterns and ownership rights, knowledge of which takes time to build but is important for the customized delivery of P3-System services. Similarly, geotemporal user profiles, which can be refined over time to include information such as important places of work and leisure, affinities, and social ties, can help in the provisioning of P3-System services. Finally, the approach of completely independent development and deployment of P3-Systems exacerbates the problem of finding a critical mass of users to make the service of value.

The SmartCampus Initiative: Giving an Urban Campus Social Smarts

THE NJIT URBAN ENCLAVE

Situated in downtown Newark, New Jersey Institute of Technology (NJIT) is the largest comprehensive technology focused university in the New York metropolitan area. The NJIT campus is geographically compact and its immediate surroundings include other Universities (such as Rutgers Newark), the Newark Museum, and various historic churches. During a typical semester workday, two to five thousand individuals come to NJIT, many of whom are associated with neighboring institutions. However, despite the potential for social connectivity provided by this increasingly rich urban environment, NJIT's students, who are ethnically diverse, technology conscious, and mostly male, have expressed dissatisfaction with campus social life and their ability to make new campus social ties. It is within this dynamic urban environment that through our '*SmartCampus*' initiative, we are systematically studying location-aware social computing. Our aim is to improve geographically concentrated social connectivity through the deployment of the suite of P3-System applications linked to a unified backend and middleware layer, specifically designed to tie together users of the NJIT Urban enclave.

TECHNOLOGY ENVIRONMENT

Since a key aim of our research is to understand the impact of the routine use of location-aware social software, we see it as essential that the applications we deploy can be widely adopted by individuals with everyday consumer computing devices such as cell phones, PDAs, Laptop and TabletPCs. Therefore, we have chosen to enable ongoing location-awareness through technologies available on portable consumer devices such as Intel's PlaceLab [11]. Recognizing that no single location technology is ideal and that in we will have to support heterogeneous devices and technologies, we have decided to initially focus on the use of WiFi technology, finding work-a-rounds for its limitations, and complementing this work with an exploration of cellular solutions.

NJIT provides users of its campus with blanket WiFi coverage, but accurate WiFi locatability requires significant redundancy in wireless coverage so devices can determine their position through triangulation or identification of unique patterns of wireless coverage (fingerprinting). Therefore, we are complementing NJIT's WiFi network through careful placement of low cost 'dummy' access points. These dummy access points are only used to enable highly accurate wireless location fingerprinting. This WiFi coverage is then used to support: 1) mobile client device-side location identification using access point centrally and fingerprinting measures; and 2) infrastructure side location identification primarily for place-centered P3-services. We will also plan to match the WiFi positioning with judicious use of user's diary/schedule information and client side positioning through cell tower signal fingerprinting and network side positioning in partnership with cellular operators.

For urban enclave-scale social computing to succeed, it is essential that the environment contain a large number of individuals with the appropriate consumer technology. With National Science Foundation and NJIT support, we are purchasing and distributing hundreds of devices, with our software installed, to students. We can categorize the devices as either mobile (e.g., cell phones) or nomadic (e.g., laptops). We are gradually providing hundreds of individuals with phones that have WiFi, Bluetooth, keyboards, stylus input, and provisioning for cellular signal location fingerprinting (Imate K-Jam and similar models). These mobile devices can capture geotemporal personal data and support lightweight location-aware applications. Nomadic devices are not designed for continuous mobile use or reachability, but for the provision of a computing desktop, that enables work in multiple locations. They are good for the identification of users' work places, the provision of P3-System services that require larger screen *in situ* data management, and expanding the connectivity options of enclave users.

SMARTCAMPUS P3-SYSTEMS

The initial suite of *SmartCampus* P3-Systems includes:

CampusWiki, a context-aware campus community Wiki that provides editable pages about campus places, people and organizations. Wikis support communities by enabling the creation of shared knowledge bases through collaborative authoring. Traditionally, Wiki content generation and retrieval are disconnected from the physical environment of users. Thus, the users' ability to support the creation and use of knowledge bases tied to relevant places for local communities is limited. *CampusWiki*, is location-aware, providing users with location relevant content and editing tools for better socio-geographical navigation. The application is popular amongst students and doest not require special devices for use. Of interest to our team has been the popularity of location-relevant content, as demonstrated by an analysis of click stream data. We are using *CampusWiki* generated data to enhance our enclave middleware profiles of places and people on campus. In addition, we are using it to explore how community data generated from use of social computing applications can support organizational practices.

CampusNavigator enables place-centered "buddy awareness," place-centered instant messaging, placed based recommendations and information primarily for use on mobile devices (although a matching desktop version is being developed). A core feature and research concern associated with *CampusNavigator*, which is supported through our middleware is a system, is that it allows users to simultaneously leverage individual and community mobility traces to identify, analyze and label places of relevance on campus. The labeling process is supported by a social tagging system or folksonomy of campus places. In addition, place based information is extracted from users' location-linked commentaries (through *CampusWiki* and/or *CampusNavigator*).

CampusMesh, a location-aware social reminding, coordinating, and introduction system, which we will describe in more detail below with activities scenarios that will illustrate its value as a community and research tool, and its dependency on a sophisticated middleware layer.

SmartCampus SocialDesktop is a dynamic friend-of-a-friend application that supports contact management practices across all *SmartCampus* applications (e.g. adding a buddy to ones cell phone CampusMesh contact list). The application also leverages knowledge of community mobility patterns to improve the profiling of user preferences and social ties. A core research concern is how we can create a social-networking application that provides simultaneously a quality user experience and encourages users to accurately represent they campus social network. If we are able to achieve this research goal the changes in users' *SocialDesktop* over time will represent changes in the nature of users' social ties.

SmartCampus Assistant is used to load these other applications, set global privacy settings (locatability and interruptability) and help us model user behavior through the provision of mobility trace data.

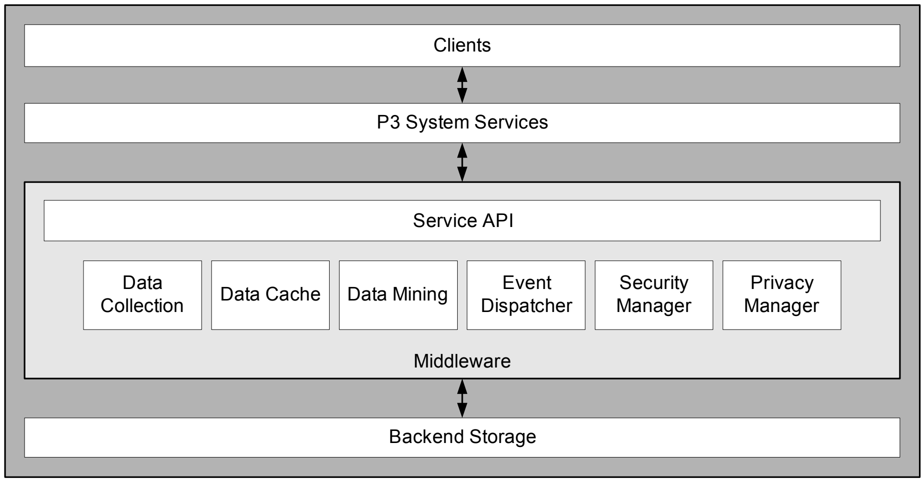
SMARTCAMPUS MIDDLEWARE AND ENCLAVE MODEL

The *SmartCampus* middleware supports each of the eight basic P3-System design techniques, as presented in Fig. 1. Typically, an application consists of two components: (1) a thin P3-System client that resides on a nomadic or mobile device; and (2) a P3-System service built on top of our *SmartCampus* middleware. The *SmartCampus* middleware securely collects individual, community, place, and social event data from associated client applications, and environmental sensors. This data is continually mined to produce an increasingly rich model of the enclave environment. Unlike typical distributed middleware solutions, our middleware not only shields the programmers from distributed heterogeneous hardware, but also provides social models of urban enclaves and allows a large spectrum of P3-System services to access data derived from these models in a simple and secure way through a service API. Furthermore, instead of running on client devices our middleware runs only on the servers maintained by an enclave's trusted organization such as university or community association.

More specifically, the *SmartCampus* middleware has six components, as illustrated in Fig. 1. that capture the geo-temporal and social data in the urban enclave, model the characteristics of the environment, and share the derived data among multiple P3-System services. In the context of our human centered computing efforts two of these modules deserve a more detailed discussion.

- *Data Mining* – This module uses the data collected to infer enclave places from mobility traces, and appropriate place labels from social tagging, and affinities among individuals or groups of users from explicit and implicit preferences, social ties between users, reputation measures and more. For instance, user profiles can be enhanced with information inferred from geo-temporal data (e.g., the user has a weekly meeting with two of his classmates in the library). Social events can also be detected by analyzing the geo-temporal and social data. Feedback from users can be assessed to confirm the conjecture of the system. The data produced during data mining can be stored either in the Data Cache for faster real-time sharing among active users or in the backend storage for future use. Furthermore, the Data Mining module interacts with the Event Dispatching module each time it identifies new affinity matches in order to forward match alerts to users.
- *Privacy Manager* – privacy is a big concern when one plans to collect, mine, and share geo-temporal social data [3]. Carefully designed privacy mechanism and privacy-enforcing policies at every layer in the system architecture need to be implemented to alleviate privacy concerns. For instance, we introduce privacy preserving techniques during data mining (e.g., anonymizing data) and real-time social matching (e.g., cloaking the location of a person during social introductions, providing tools for user controlled progressive identity revelation). We also allow the users to control the desired levels of privacy and assign variable trust levels to different user groups.

Figure 1 – *SmartCampus* System Architecture and Middleware



To illustrate the concept of a P3-System service and its interaction with the middleware, we provide some *CampusMesh* activity scenarios. *CampusMesh* is a location-aware geotemporal social matching (for discussion of this class of system see [12] & [6]), reminding and coordination system. It aims to encourage the formation of new friendships, and supports goal directed team formation, and geo-temporal personal relationship management through various use of various people-centered P3-techniques. The system is dependent on a rich social world model and uses knowledge of campus places, people and friendships to provide appropriate alerts and ensure user privacy. We aim to make the system trustworthy by providing users with appropriate levels of control for the revelation of their personal data to other users, especially between individuals who have had little contact with each other. The following three CampusMesh user-scenarios illustrate the system and the types of services implemented:

1. Geo-Temporal Reminding Scenario

Mike, Joe, and Fred regularly meet at a computing laboratory to study for their Ubiquitous Computing class. Joe keeps bringing a textbook borrowed from Mike that needs to be returned to the library, but every time they meet, other stuff comes up and he forgets to return it. Finally, he decides to set a reminding alert triggered by proximity to Mike. When they meet next time, the CampusMesh client delivers the reminder; Mike gets his book back and then returns it to the library. Later in the day mike meets with a group of faculty and students about a proposed new student faculty rating system. Just before the start of the meeting, Mike uses a mix of CampusMesh buddy proximity-awareness information and the friend-of-a-friend profiling system to remind himself about the other people that will be attending.

2. Geo-Temporal Coordination Scenario

The exam for CS 330 is approaching, and Tiberius would like to study together with classmates. Since he has three free hours between two classes, he decides to use CampusMesh to look for classmates that are currently on-campus and willing to study together. The CampusMesh service identifies a number of students that are available on-campus (e.g., they are not taking a class at this time) and based on their schedule decides to alert four of them about Tiberius' request. Out of those four, two people answer positively and propose to meet in the Campus Center. In this scenario, CampusMesh sets up a meeting on-demand considering both the profiles (i.e., the classes they take or their current schedule) and the current geo-temporal data of the users.

3. Geo-Temporal Social Matching Scenario

One afternoon, Ayala is relaxing in the Campus Center when her phone vibrates with an affinity match alert. She sees that it has detected another female student with a high affinity match in the vicinity, someone she might wish to meet. Though the system does not reveal the stranger's identity, it does inform Ayala that they have several friends in common and a mutual interest in classic science-fiction films. As Ayala is hoping to organize a science-fiction film festival on campus, and despite her wariness about meeting strangers, she uses CampusMesh to find out more. After further information is *exchanged through progressive identity revelation controlled by each user, she decides that a meeting is appropriate.*

Figure 2 - Social Matching in CampusMesh

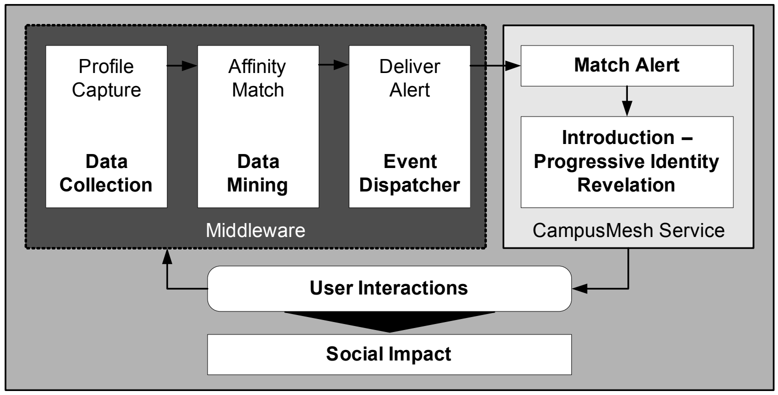


Fig. 2 depicts the interaction between the CampusMesh service and the middleware for the last scenario. Once the P3 profile matching service (initiated by either *CampusMesh* or *SmartCampus SocialDesktop*) has informed the middleware about its set of users, the middleware captures the user profiles and their geo-temporal histories. The Data Mining module, models the set of users and identifies affinity matches. A newly identified affinity match will prompt the Event Dispatcher module to trigger a match alert that is delivered to the service. The service incorporates an introduction mechanism that allows the users to progressively reveal their identity in a privacy-compliant fashion. Finally, the results of user interactions will be fed back into the middleware to improve its social models.

SMARTCAMPUS USABILITY AND SOCIAL IMPACT CHALLENGES

To achieve our goal of deploying a suite of interconnected P3-systems that increase social connectivity in our urban enclave, our applications have to be both widely adopted and increase social ties between community members. This requires that applications developed meet both users needs and operate in ways that are deemed social acceptable (e.g. they are not perceived as overly privacy invading or annoying). In addition, we must also monitor social connectivity and how it is impacted upon by our social computing systems to ensure that applications are actually achieving our social goals.

To maximize utility and usability, and to minimize possible negative social impacts of SmartCampus applications, we are involving our community in all stages of design. As part of this process, prior to the release and detailed specification of our initial set of SmartCampus applications, we conducted 65 semi-structured interviews aimed at understanding better the potential needs and concerns of our user community. The open-ended questions explored prospective users' initial attitudes towards possible 'generic' P3-System applications, within a our urban enclave context. The interviews focused on perceived benefits, their concerns, and their intention to use such services if available (more detail can be found in [7]).

The level of interest in using the SmartCampus applications in the future, and concerns raised by the respondents show some widespread attitudes of people towards the privacy issue that must be taken into account in the design and deployment process. The content analysis results find more passages associated with concerns, a significant portion of which are about privacy, than those associated with benefits (177 vs. 151). Nonetheless, vast majority of respondents said that they would be willing to use the SmartCampus applications. This could be an artifact of it being easier to talk about concerns about an unseen application than benefits, or perhaps reflective of previous findings that people can be divided into three groups in terms of their attitude towards privacy: the marginally concerned, the privacy fundamentalists, and the pragmatic majority. Our community seems to belong to the pragmatic majority who may trade privacy for benefits. Although they are concerned about privacy, they would use the applications because expected benefits may exceed their concerns.

These findings about user perceptions, supported by related surveys and usability studies [4], have a number of fundamental design implications. One is that privacy and information management, for our user-community, goes hand-in-hand. Individuals want P3-System services but they want to be able to ensure that they are not inappropriately interrupted, inundated with inappropriate messages, or constantly required to manage their availability settings. As a result, we believe that we need to provide users with:

1. A simple user interface on both mobile and desktop personal computing devices for the unified management of personal global SmartCampus privacy settings. Settings modified on this interface should be able propagate to all SmartCampus applications such as *CampusMes*h, *CampusNavigator* and *CampusWik*i. However, as part of our ongoing research in this area we are also exploring when and where privacy settings are truly application specific and should require direct manipulation by the user.

2. Privacy management tools that enables users to simultaneously adjust both locatability and interruptability / availability. Users were often willing to be located but not interrupted (e.g. "I am happy for my friends to know I am in class, but to IM me") and as a result want control over these aspects.

3. The ability to set their preferences so that they are semi-automatically implemented (context-aware [1]) by the system based on location, time and social connectivity. Respondents were clear that they want to get location relevant alerts and provide their personal location data to others, but they want the applications to be smart enough not to overload them with alerts or to have to change to work hard remembering when they should be switched to a more private mode of operation. This will require considerable work on our part in building mechanisms for the identification of individual and community places on campus, and understanding how places related to general privacy preferences. Work that we are actively engaged in through the development and deployment of our *CampusNavigator* application.

To build on and complement this work, we are measuring and tracking student and faculty social and professional networks on campus, using a social network mapping techniques and instruments [10], as well as our *SmartCampus Social Desktop* application, which provides users with an interface that allows them to see and leverage their campus social ties.

From Urban Enclave Computing to Societal Systems

As our overview of the *SmartCampus* initiative shows, giving an urban enclave 'computer enabled social smarts' is not simply about the provision of individual innovative ubiquitous computing environments, such as context aware SmartRooms, nor is it about the provisioning of applications that are disconnected from the local community context. Rather, it is about enabling communities of users with infrastructure and applications that improve geographically concentrated social connectivity. A key challenge toward deploying high impact P3-System services is how to encourage users to regularly generate semantically rich descriptions of places and events, geocoded personal content, and geotemporal personal mobility traces that can then be used to enhance personal and community profiles. New social software techniques provide some clues, but of course for users to be comfortable with providing such data they will have to both see value in the services offered and have many of the significant privacy concerns associated P3-systems allayed.

During the 1990's, applications of a wired Internet transformed the computing world and the social system. Presently Web 2.0 applications are changing the ways in which we work and play. In the next decade, social ubiquitous computing will have a similar impact as basic design and usability issues are overcome. We believe that the creation of rich social computing enclaves that generate and utilize sophisticated models of social and physical geographies will provide the basic building blocks for the emergence of even larger-scale societal systems. Such systems will leverage knowledge of the social connectivity in multiple urban environments to address issues that confront cities and regions such as public health and environmental resource utilization.

References

1. Abowd, G. and Mynatt, E. Charting past, present, and future research in ubiquitous computing. ACM Trans. Computer-Human Interaction. 7, 1 (Mar. 2000), 29-58.
2. Griswold, W. G., Boyer, R., Brown, S. W., Truong T. M., Bhasker E., Jay G. R., and Shapiro R. B.,

ActiveCampus - Sustaining Educational Communities through Mobile Technology", Technical Report CS2002-0714, Computer Science and Engineering, UC San Diego, July 2002.

3. Hong, J.I., et al. Privacy Risk Models for Designing Privacy-Sensitive Ubiquitous Computing Systems. In Proceedings of Designing Interactive Systems (DIS2004). Boston, MA. pp. 91-100 2004.
4. Jones Q. Grandhi SA., Karam S., Whittaker S., Zhou C., and Terveen L., (In Press) Geographic 'Place' and 'Community Information' Preferences. *J. Computer Supported Cooperative Work.*
5. Jones Q. Grandhi SA., Terveen L., and Whittaker S., "People-to-People-to-Geographical-Places: The P3 Framework for Location-Based Community Systems," *J. Computer Supported Cooperative Work*, vol. 13, nos. 3–4, Aug. 2004, pp. 202–211.
6. Jones, Q and Grandhi, S.A. "P3 Systems: Putting the Place Back into Social Networks. *IEEE Internet Computing*, vol. 09, no. 5, pp. 38-46, September/October, 2005.
7. Kim E., Plummer M., Hiltz S.R., and Jones Q., (2007) "Perceived Benefits and Concerns of Prospective Users of the SmartCampus Location-Aware Community System Test-bed". Hawaii International Conferences of the System Sciences.
8. MIT "iSpots: Living and Working on MIT's Wireless Campus" 2005. Available online at: iSpots.mit.edu
9. Paulos E., and Goodman E. The familiar stranger: anxiety, comfort, and play in public places. CHI 2004: 223-230.
10. Plotnick, L.S. and Hiltz, S.R. Measuring Social Networks for SmartCampus. Proceedings, America's Conference on Information Systems, Acapulco, August 2006, CD Rom.
11. Schilit B. et. al. Challenge: Ubiquitous Location-Aware Computing and the Place Lab Initiative. In Proceedings of The First ACM International Workshop on Wireless Mobile Applications and Services on WLAN, San Diego, CA. September 2003.
12. Terveen, L. G. and D. W. McDonald (2005) Social Matching: A Framework and Research Agenda. *ACM Transactions on Computer-Human Interaction*. 12 (3), pp. 401-434.

Biographies

Quentin Jones Ph.D. is an Assistant Professor in the Information Systems Department at NJIT. He is the director of the SmartCampus Project.

Cristian Borcea Ph.D. is an Assistant Professor in the Computer Science Department at NJIT.

Starr Roxanne Hiltz Ph.D. is Distinguished Professor in the Information Systems Department at NJIT.

Brian Amento Ph.D. is a Senior Technical Specialist AT&T Labs - Research and Research Professor in the Information Systems Department at NJIT.

Constantine Manikopoulos P.E., Ph.D. is the founder and director of the NSF Center for Information Protection (http://CIP.NJIT.EDU) at NJIT and co-founder and co-PI of the New Jersey Center for Wireless Networking with Internet Security (NJWINS).