Using Mobile Technology to Create Opportunitistic Interactions on a University Campus*

William G. Griswold, Robert Boyer, Steven W. Brown, Tan Minh Truong,
Ezekiel Bhasker, Gregory R. Jay, R. Benjamin Shapiro

Department of Computer Science and Engineering
University of California, San Diego
La Jolla, CA 92093-0114
{wgg,rboyer,sbrown,mtruong,ebhasker,gjay,rshapiro}@cs.ucsd.edu

Abstract

The traditional university campus is designed to foster a thriving community of learners, but modernity has introduced many stresses. Mobile computing holds the potential to strengthen a campus's traditional institutions of community by creating serendipitous learning opportunities through a process of indirect mediation. This paper introduces ActiveCampus, a suite of personal services for sustaining an educational community based on this idea.

1 Introduction

With the arrival of the baby boomers' children, the University of California, San Diego (UCSD) is quickly growing from an intimate small town into a bustling city full of unfamiliar faces. Building proceeds apace, with dozens of departments and hundreds of labs and institutes finding homes in odd corners of undistinguished buildings, old and new. This rapid growth has brought numerous "big city" stresses. It is hard to keep up with the building on campus and who occupies what building. Unfamiliar faces are everywhere, even obscuring those that you know. With growing diversity and the inability to build as fast as people arrive, more students work and live off campus, making them visitors to their own campus and education. One third of undergraduates transfer to UCSD after two years at another college, abbreviating their campus experience.

These changes strike at the heart the campus's mission of learning—research and education. With this mission comes a culture that believes in the power of knowledge to transform people and the world in the most positive way. The university campus, as originally conceived, was a place to nurture those values and pass them on to the next generation, a kind of perpetually rejuvenating cocoon. In becoming a city of towns, and perhaps a city of visitors, UCSD could lose its transformative powers—or it could magnify them. The latter requires new ways for people to stay in touch with old colleagues, meet new ones, and become aware of the exciting opportunities around them.

While the campus administration pursues new policies and institutions to keep our community strong, the ActiveCampus project is exploring the use of technology to meet this challenge. With assistance from Hewlett-Packard, we are giving HP Jornada PDA's with 802.11b wireless to 700 undergraduates studying computing at UCSD. With UCSD's wide deployment of 802.11b access, we are able to explore research questions in sustaining educational communities through mobile computing.

Sustaining dispersed communities through virtual spaces is well known [Rhe00]. Direct support of physical communities is seen in the discourse enabled by E-Graffiti [BG01, BGar] and GeoNotes [EPS+01], where users can leave their electronic thoughts in physical space for those who follow (See Section 3.2). These projects provide a compelling application and warn of the need for a large community and sufficient content to be successful.

Our approach is a variant on a familiar theme[MM99, NIH01, OS00, LKAA96, PBC+01, DCME01]: if you and every person on campus carried a mobile, wirelessly connected device, then it could be used as a kind of "x-ray glasses" onto your immediate vicinity that would let you see through the crowds and undistinguished buildings to reveal nearby friends, potential colleagues, departments, labs, and interesting events. By making the clutter transparent

*This work is supported in part by a gift from HP, support from the California Institute for Telecommunications and Information Technology (Cal-(IT)^2), NSF Grant IIS-9873156, and the ActiveWeb project, funded by NSF Research Infrastructure Grant 9802219.

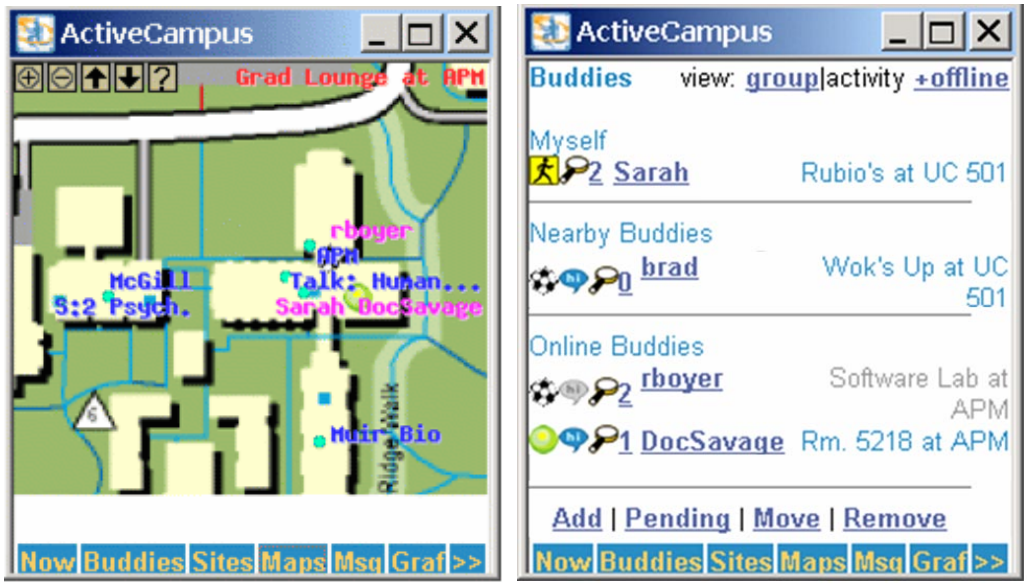

Figure 1: The Map and and Buddies pages of ActiveCampus, as shown on an HP 548 Jornada. Map shows an outdoor or indoor map of the user's vicinity, with buddies, sites and activities overlaid as links at their location. Buddies shows colleagues and their locations, organized by their proximity. Icons to the left of a buddy's name show the buddy on the map, begin a message to the buddy, and look at graffiti tagged on the buddy. Separate pages, reached by the navigation bar or clicking embedded links, show lists of sites, graffiti, and buddies, and performing operations on them.

and highlighting otherwise invisible things, once-unnoticed opportunities are now apparent, creating serendipitous opportunities for learning.

A simple realization of this idea appropriate for a small wireless device like a PDA is shown in Figure 1. The large area is a map of a person's immediate vicinity, as detected through some geolocation method. Overlaid are links showing the location of nearby departments and friends. Department links and the like can be followed to bring up a web page. A nearby colleague, formerly no more available for lunch than a hundred others, is seen to be in the vicinity and can be instantly messaged or found on foot. Any place or entity can be tagged with digital graffiti, supporting contextual, asynchronous discourse.

ActiveCampus is a working system available for use by everyone at UCSD. It is in active use by our group and several others (about 20 in number) and is being deployed in stages to our existing base of Jornada users for beta testing. All the functionalities described in this paper are operational unless otherwise stated. As part of a broader project using the campus as a living laboratory, researchers in the department of Communication are conducting ethnographies to understand ActiveCampus's impact on campus life.

This paper makes three contributions. First, it identifies a set of sociological issues and places them in a conceptual framework that clarifies how technology can contribute. Second, it defines a base set of services necessary to sustain a community through mobile computing. Third, this definition is instantiated with a particular design and implementation suitable for small form-factor wireless devices. Before closing, we lay out some future work in using technology for opportunistic interaction that must be resolved, along with our current thinking on these issues.

2 Theory and Requirements

Learning activities, spontaneous and otherwise, are heavily mediated (assisted) by a university campus through its structural configuration and its institutions.[1] First, the campus organization itself brings people with complementary interests into close proximity, easing communication and increasing the chances of serendipitous interactions. The campus not only brings learners and teachers together, but also concentrates area specialists by organizing the campus into schools and departments of expertise (such as schools of Engineering and departments of Computer Science).

[1]Here, we interpret institution broadly, including entities like departments, libraries, seminar series, and even people. The notions of mediated learning described herein are informed by the work of Michael Cole [Col96].

A department is not just an aggregation of interest, but is a full-blown institution providing services for its aggregate of people, including working spaces, meeting spaces, seminars, opportunities for chance interaction, equipment, curricula, degree programs, funding, etc., to enable and encourage the processes of learning.

Because these institutions operate through proximity, they function less well when people are not "there" on a full-time or full-attention basis. Moreover, it can take considerable time for someone to internalize the workings—the culture—of an institution. If someone does not know the internal workings of an institution (for example, how talks are scheduled and where they normally occur) its mediating power is lost on them, and indeed possibilities are disguised (when it is possible to drop in for a talk). When such obfuscation is combined with a busy schedule, conflicting priorities, distractions, interruptions (half of UCSD undergraduates possess cell phones), it is not surprising that many opportunities are missed. Further complicating matters is that many campus institutional structures crosscut each other, creating ambiguity, but also richness. For example, UCSD is divided into residential college neighborhoods. Each department sits in a college neighborhood and is nuanced by it, but does not belong to that college; it belongs to a school. Each faculty member belongs to a college, however, and of course a department.

We hypothesize that mobile computing applications, by mediating the institutional mediation of learning, can accelerate one's on-going acclimation process, thereby mitigating time and attention deficit. In such a role, ActiveCampus is not a replacement or proxy for extant institutions, but rather a facilitator. Such a role befits mobile devices, given (on the negative side) their limited form factor, interface, and computing power, as well as (on the positive side) their mobility and relative unobtrusiveness.

Building on the idea that a campus organizes institutions for mediating learning, it is natural to consider reifying (displaying) contextual information about (a) you (the learner), (b) mediating institutions, and (c) the sources of learning enabled by those institutions such as a professor, friend, book, event, or another institution like a lab. Since a campus institution is typically a physically aggregated entity, displaying an institution in a *transparent* form and showing its mediated sources of learning "inside" it (or even next to it) is a natural way to convey mediating relationships. Depending on the possible relationships between the learner and the learning source (including role reversal), participants may need the ability to talk—as well as see—through walls. Gradually, then, through experience, a participant learns to parametrically associate the institution with learning sources, imbuing the institution with its full power.

There are many research efforts on augmenting the physical world with information from virtual spaces, albeit without an explicit focus on communities, culture, and learning. At ATT Research Cambridge, users wear goggles which overlay information to enhance their knowledge of what they are already seeing [NIH01]. Hippie [OS00], CyberGuide [LKAA96], GUIDE [DCME01], and a host of other electronic tour guides provide information for the user about the local surroundings using a mapping metaphor to abstract the world, making physical boundaries transparent, and thereby expanding the horizons of the user. These interfaces typically include links to allow the user to drill down for more detailed information. HP's Cooltown [PBC+01] creates a web presence for people, places, and things to support users as they go about their everyday tasks. IR Beacons, RF ID tags, and bar codes are used to identify elements in the environment.

3 ActiveCampus Scenario

3.1 A Day with Sarah

Sarah, a UCSD computer engineering sophomore who transferred from Mesa Community College last quarter, walks out of her morning Engineering 53 lecture, introduction to electrical engineering. This isn't what I signed up for, she's thinking, wondering where was the engineering her Dad had told her about—building things that improved people's lives? Flipping open her PDA, ActiveCampus shows a map of her vicinity, and she sees a link to a talk with "human" in the title (Figure 1, left).[2] Clicking through, she sees there's a talk just starting in the engineering building on the human-machine interface. Curious, she decides to go. Although the talk gets technical quickly, the introduction has shown her a link between people and computer engineering.

Realizing she's hungry, Sarah heads to the Price Center for some lunch. Her usual table of friends is probably gone by now. Really wanting to talk to someone about adjusting to UCSD and her major, she checks ActiveCampus (Figure 1, right) and sees that her "buddy" Brad is nearby and active (both location and message icon highlighted in blue), clicks on him and sends him a "Wanna go eat?" with a couple of clicks (Figure 2). Brad notices the "dome" on his PDA flashing,[3] and flips it open to see that Sarah has sent him a message and is nearby. Now both looking for each

[2] ActiveCampus uses the PDA's report of all sensed 802.11b access points and their relative signal strengths to infer a location [GBB+02].

[3] The flashing dome feature has been prototyped but is not yet deployed. ActiveCampus also uses the second line of each page to convey events like a new message arrival.

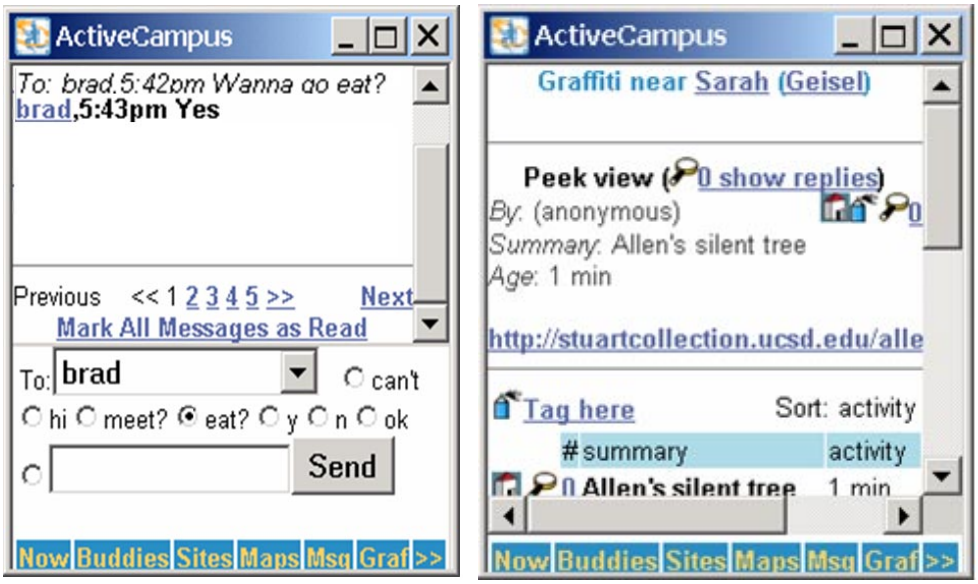

Figure 2: The Messages and Graffiti pages of ActiveCampus.

other, they see each other through the lines of people and sit down to talk about their day.

After lunch, Sarah decides to go to the library to get a head start on her Engineering 53 homework. Later, leaving the library, she notices that the tree outside the library is not dead, as she'd thought—it's made out of metal and talking quietly. That's so weird. Flipping open her PDA, she clicks over to the digital graffiti page of ActiveCampus, since a friend told her there was lots of arts stuff in there (by default graffiti is not shown on the map since it can clutter). There is a list of graffiti that's been "tagged" in the area, including a "living dead tree" link near the top (Figure 2). Clicking on different parts of the tree leads to different parts of an interactive artwork. Clicking on the tree's roots leads to a story about the tree, pointing her to other talking trees on campus, and gives the lowdown on UCSD's Stuart art collection. Now she begins to understand all the weird stuff she'd been seeing on campus! Clicking on the spray can to the left of the graffiti's subject line, she is taken to a page where she "tags" the interactive tree with a "Thanks tree!" note to be seen by others who view the living dead tree via ActiveCampus. Walking off, she thinks, huh, I wonder if there is a role for art in engineering? She'd have to ask Mark about that.

3.2 Discussion

Sarah's day reveals several crucial properties of ActiveCampus. The most notable is that it helps campus denizens see through the unintentional barriers created by institutions. Sarah can see that there is a talk starting nearby, even though it was only officially disseminated to the campus via posters in engineering building hallways. Even if she had seen these posters earlier, it would not have been in the context of her frustrating day and probably long forgotten. Seeing a talk with "human" in the title, and in an engineering building, was her cue that this talk might be especially relevant to her. This is a function of mediation—the particulars in the scope of the general establish a context for interpretation.

ActiveCampus has similar, but not identical, benefits at the Price Center food court and library. In the Price Center, the mere concentration of people is the barrier created by the institution, but the context is eating, which implies relatively unstructured time—a friend of hers at the Price Center is probably free to chat. ActiveCampus merely provided the "final mile" solution, timely and contextualized information about her surroundings.

Colleague Interactions. Sarah's use of the buddy features are indicative of ActiveCampus's facilitator role. After helping her notice that her friend Brad was nearby, she used messaging and his displayed location to purposefully find him. If many friends were nearby, she could have messaged all nearby or active buddies in one action to speed the process. In this way, Sarah is using ActiveCampus to maintain and even develop her social network in a chaotic context. ActiveCampus's messaging does not replace e-mail or instant chat, but incorporates ideas from each to create a service that can unobtrusively help arrange meetings in the physical world. There are no pop-ups (they are disruptive) or conversational threads (if you can't remember the context for a message in an on-going conversation, the opportunity for meeting is likely passed), and simple meeting-directed messages can be sent with a couple of clicks.

Revealing one's location on ActiveCampus could lead to unwanted interactions. Thus, before Sarah could see Mark on her PDA (or vice versa), both she and Mark had to add each other as buddies—a *mutual acceptance policy*. In an ad hoc community, it might be hard to buddy-up spontaneously with such a method. At UCSD Sarah can use Mark's campus e-mail name to add him to her list. She didn't have to ask him for his ActiveCampus ID or exchange contacts with someone else. In fact, UCSD has a "finger" service that maps names to e-mail names.

Digital Graffiti. Sarah used digital graffiti to answer the question "What is this tree?" because there was no official link for the tree. Consequently, she found out not only what the tree was, but what other people thought about it. This is beneficial to Sarah because she is discovering that this is not just a campus of busy, stuffy professors lecturing to quietly listening undergraduates, but a place where people just a bit "ahead" of her are participating in the campus's academic life. Thus, as with discovering the talk, Sarah has—conceptually—seen through the walls of an art studio to see the campus in action. In actually posting her own graffiti, Sarah has taken an important step from being a passive visitor to a campus citizen involved in community discourse.

Many of digital graffiti's possibilities are not revealed in Sarah's day. Any ActiveCampus entity can be tagged: a static object such as a restaurant (e.g., "Get the ham sandwich, it's great!"), physical location (e.g., someone's favorite sunset locale), transient object (e.g., a buddy), or other graffiti. Through artistic expressions, political debates, and the like, graffiti can become a valued record of campus life. For example, a student might learn what others thought about recent concerts held at a campus venue, find links to band web sites, etc., helping people choose amongst opportunities.

Actual Experience. Our own use of ActiveCampus has not been unlike that of our character Sarah. What follows are a few examples of serendipitous interactions created by ActiveCampus.

- Ben drops by Bill's office, but he's not there. Ben checks his PDA and sees that Bill is at the cafeteria across the quad. Ben heads over to the cafeteria and joins Bill and Jens for lunch.
- Bill is stuck in a late meeting and sees that Pat is still in his office, despite the late hour. A quick message confirms that Pat will still be there in a half hour, and a much-needed meeting takes place.
- Bill is late for a meeting, but has to pick up some lunch first. The group waiting for him sees that he's in the "line" area at the food court, and concludes that he'll be arriving shortly.

4 Future Work

Since ActiveCampus is not yet widely deployed, Many issues remain to be explored and evaluated. Here we lay out two open issues and our current thinking on them.

Time-shifted and place-shifted Opportunities. Sometimes an opportunity can be perceived in the future, for example buying a book at the bookstore the next time I am nearby. To ease cognitive load, ActiveCampus could be extended with user-specified contextual alarms to provide the needed reminder.

Fortuitous Discovery. Given the small size of mobile devices and one's limited time, the opportunity glut created by a university must be managed, but at the risk of feeling like censorship. One small step we've taken is the Now page (not shown), which uses biased random selection and abstraction to condense without losing the chance for discovery.

Conversely, given participants' privacy needs, how can ActiveCampus help, for example, bring together two "birds of a feather" who are unknown to each other? We are investigating the use of *asynchronous negotiated access*, which can ease the sharing of information without excessive information exposure [HS00].

5 Conclusion

UCSD, like many campuses, is adjusting to a growing, changing student body that may feel more connected to off-campus life than on-campus life. Although mobile technology is part of the problem, it can also be part of the solution. Employing the contextual display of campus participants, their institutions, and the learning opportunities enabled by those institutions through the metaphor of transparency, it is possible to make campus life as compelling and opportunistically accessible as off-campus life.

We have identified a set of complementary services that we believe can achieve this goal. By using the context of location, time, and one's stated colleagues, a display in the form of a map or labelled list helps a participant see opportunities that are within reach and act upon them by physically moving to them or clicking on their links to learn more.

When that opportunity is talking to a colleague, click-driven messaging facilitates a meeting. Our colleague subscription method is simple, unobtrusive, and respects privacy. ActiveCampus augments campus discourse through digital graffiti, the ability to virtually "tag" locations, entities, and other graffiti with commentary or artistic expressions.

Ubiquitous delivery and the relatively seamless integration of different services for small devices presents challenges not discussed in detail here [GBB+02]. ActiveCampus is a server-side application supporting browser-based clients, providing lowest-common-denominator ubiquity. Added functionality such as geolocation and message notification is provided in separate micro-applictions, if the platform can support them. In the server software, establishing the *site*—a campus entity with a name, location, and default action-on-click as a system supertype permits new services to define themselves as subtypes of site. Then, generic displays like our map view can display all (desired) site types in a single display in a natural fashion. The unique features of a service are accessed through a custom display that is made available through a simple navigation bar, or perhaps also through the default action-on-click.

We are now deploying ActiveCampus in stages to our population of 700 Jornada PDA users, and preparing for ethnographic investigation of its impact on campus life. Many open problems remain, both social and technical. Issues such as bootstrapping community and content, and balancing the needs of chance discovery and information management are just two. We hypothesize that our approach of augmenting existing institutions, rather than replacing them, will help.

Acknowledgements. We thank Jim Hollan for his philosophical and technical guidance on technology-sustained communities. We thank UCSD's Facilities office, in particular Roger Andersen, Robert Clossin, and Kirk Belles, for their their time, expertise, and resources. Thanks to Ed Lazowska for reading a draft of this paper. We thank David Hutches, Jadine Yee, Justin Lee, Daniel Wittmer, Antje Petzold, Jean Aw, Linchi Tang, Adriene Jenik, and Jason Chen for their assistance on the project. Finally, we thank Intel's Network Equipment Division for donating network processors and Symbol Technologies for their software technical support.

References

[BG01] J. Burrell and G. K. Gay. Collectively defining context in a mobile, networked computing environment. In *CHI 2001 Extended Abstracts*, May 2001.

[BGar] J. Burrell and G. K. Gay. E-graffiti: Evaluating real-world use of a context-aware system. *Interacting with Computers*, To appear.

[Col96] M. Cole. *Cultural Psychology: A Once and Future Discipline*. Harvard University Press, Cambridge, MA, 1996.

[DCME01] N. Davies, H. Cheverst, K. Mitchell, and A. Efrat. Using and determining location in a context-sensitive tour guide. *IEEE Computer*, 34(8):35–41, 2001.

[EPS+01] F. Espinoza, P. Persson, A. Sandin, H. Nystrom, E. Cacciatore, and M. Bylund. Geonotes: Social and navigational aspects of location-based information systems. In *Ubicomp 2001*, pages 2–17, Berlin, 2001. Springer.

[GBB+02] W. G. Griswold, R. Boyer, S. W. Brown, T. M. Truong, E. Bhasker, G. R. Jay, and R. B. Shapiro. Activecampus - sustaining educational communities through mobile technology. Technical Report CS2002-0714, University of California, San Diego, Department of Computer Science and Engineering, July 2002.

[HS00] Jim Hollan and Scott Stornetta. Asynchronous negotiated access. In *Proceedings of Human Computer Interaction 2000*, pages 17–26, 2000.

[LKAA96] S. Long, R. Kooper, G. D. Abowd, and C. G. Atkeson. Rapid prototyping of mobile context-aware applications: The cyberguide case study. In *Proceedings of the 2nd ACM International Conference on Mobile Computing and Networking (MobiCom'96)*, November 1996.

[MM99] J. F. McCarthy and E. S. Meidel. ACTIVEMAP: A visualization tool for location awareness to support informal interactions. In *Intl. Symposium on Handheld and Ubiquitous Computing (HUC'99)*, pages 158–170, 1999.

[NIH01] J. Newman, D. Ingram, and A. Hopper. Augmented reality in a wide area sentient environment. In *Proceedings of the 2nd IEEE and ACM International Symposium on Augmented Reality (ISAR 2001)*, New York, 2001.

[OS00] R. Oppermann and M. Specht. Context-sensitive nomadic exhibition guide. In *Ubicomp 2000*, pages 127–142, Berlin, 2000. Springer.

[PBC+01] S. Pradhan, C. Brignone, J. H. Cui, A. McReynolds, and M. T. Smith. Websigns: Hyperlinking physical locations to the web. *IEEE Computer*, 34(8):42–48, 2001.

[Rhe00] H. Rheinhold. *The Virtual Community*. MIT Press, Cambridge, revised edition, 2000.