Proposed Research Essay

In a clear, concise, and original statement, present a complete plan for a research project that you may pursue while on fellowship tenure and how you became interested in the topic. Your statement should demonstrate your understanding of research design and methodology and explain the relationship to your previous research, if any. Describe how you propose to address the two NSF Merit Review Criteria of Intellectual Merit and Broader Impacts. Refer to the program announcement for specific guidance.

Format: Include the title, key words, hypothesis, research plan (strategy, methodology, and controls), anticipated results or findings, literature citations, and a statement attesting to the originality of the research proposal. If you have not formulated a research plan, your statement should include a description of a topic that interests you and how you would propose to conduct research on that topic.

Research topics discussed in your proposed plan will be used to determine eligibility. Refer to the Field of Study eligibility criterion in the program announcement.

Intellectual Merit

The intellectual merit criterion includes demonstrated intellectual ability and other accepted requisites for scholarly scientific study, such as the ability (1) to plan and conduct research; (2) to work as a member of a team as well as independently; and (3) to interpret and communicate research findings. Panelists will consider: the strength of the academic record, the proposed plan of research, the description of previous research experience, references, Graduate Record Examinations (GRE) General and Subject Tests scores, and the appropriateness of the choice of institution relative to the proposed plan for graduate education and research.

Broader Impacts

The broader impacts criterion includes contributions that (1) effectively integrate research and education at all levels, infuse learning with the excitement of discovery, and assure that the findings and methods of research are communicated in a broad context and to a large audience; (2) encourage diversity, broaden opportunities, and enable the participation of all citizens-women and men, underrepresented minorities, and persons with disabilities-in science and research; (3) enhance scientific and technical understanding; and (4) benefit society. Applicants may provide characteristics of their background, including personal, professional, and educational experiences, to indicate their potential to fulfill the broader impacts criterion.

Yaw Anokwa
Research Proposal

Have you ever wondered what forgetting your keys would be like in the world of ubiquitous computing? Imagine walking out of the house and leaving your keys on the counter. The moment your front door slams shut, an audio sensor notices you are no longer in the room and after confirmation from a motion detector, alerts an RFID scanner. The scanner knows what objects you usually take and detects your keys are still in the room. After a call to the GPS tracker in your cell phone, the scanner knows you are heading towards your office. Based on your past history, the phone now knows with a 82% certainty that you are going to your office without your keys. If the phone determines this while you are in the middle of a conversation, it vibrates. If you refuse to check and continue to head towards the office, it interrupts and rings.

The possibilities of the potential solution expand when you add a few more variables. What if you purchase a new cell phone with a heart monitor? Can the system now notice you are sprinting out of your apartment? What if you have a calendar that syncs with your PDA. Can the system know you are scheduled for a trip and potentially headed towards your car? Can it do this and guarantee some level of privacy?

Mark Weiser, a chief scientist with Xerox PARC once said, “The more you can do by intuition, the smarter you are; the computer should extend your unconscious.” Weiser’s idea that technology should fade into our environments sparked the revolution that became ubiquitous computing (ubicomp). At a time when human-computer interaction was an afterthought, Weiser proposed a paradigm shift [1] illustrated in the above example – why not make computers and computing fully invisible?

In 1996, prevailing opinion was that the age of ubicomp would start between 2005-2020, evolving computing past the current “personal computer” model. Although we are only at the beginning of that time frame, I feel that we are no closer to pushing computing into the periphery now as we were then. While we have made steady progress, we have yet to design large-scale applications that create the critical mass required for this evolution.

One potential reason behind the lack of these applications is the focused nature of current research. Literature on the subject is filled with better sensors with smarter inferencing, and more natural interfaces. However, for each of these components, a new specification or API is required. While these well-defined pieces of work are important, they simply cannot leverage the meta-data from new or existing devices to support the rich interactions needed for larger ubicomp systems. In short, ubicomp will not “emerge” from many small pieces; ubicomp needs a framework.

Attempts have been made to develop a unified framework, but rather than provide a solid infrastructure, these frameworks tend either to be concerned with a small subset of hardware [2] or to be largely theoretical [3]. Since these frameworks are designed without the goals of integration, adaptability, security and scalability in mind, those who wish to build ubicomp systems for homes and workspaces are still left with a maddening array of devices that can barely speak with each other. If we cannot guarantee seamless interaction between everything we embed, how can we expect a ubicomp environment to be natural and invisible?

The problem of frameworks seems inherent in the way ubicomp straddles both hardware and software and thus presents researchers with a unique challenge. We must have a deep understanding of both areas to realize what devices and techniques are necessary to support the crucial applications. It is impractical to expect computer science researchers to also become engineering experts, and so a possible solution is to develop a framework that addresses these core issues. Such a framework would allow both researchers and industry to begin developing ubicomp applications.

Yaw Anokwa
Research Proposal

My research approach aims to make interactions such as in the opening example as seamless as buying that new cell phone. My goals are not to create "the" standard, but rather, in the process of making a framework, to address the core tradeoffs that the field must make.

To that end, I am interested in exploring the ideas of a heterogeneous sensor net similar to Intel's Mote system [4]. While sensor nets are a great platform, they often fail to answer the broader questions that I hope to address: Should devices communicate raw or abstracted data about their surroundings? How do we assure the security and validity of the data? When should devices reconfigure? If a new user joins the system, how do we know if he/she actually belongs?

My Ph.D. work will also explore the software aspects of an ubicomp framework. The context toolkits [5] available today are a bold first step. However, instead of inferring what the user is doing, a better approach may be to generate a probabilistic distribution of the user's context. This choice will generate more questions to answer: How crucial is context in a system that actively learns about its users? Is context an effective way to predict what services a user wants? Is context a computationally efficient approach for today's devices?

I intend to answer these questions through experimentation. Based on the results, I will build a specific framework to evaluate the higher level issues. My belief is that once the core issues in my research are addressed, researchers will then be forced to focus on what combinations of hardware and software can produce the best possible applications. Industry will be able to take these research prototypes and create full systems.

I have no illusions that building a cohesive framework will be an easy task. Fortunately, the University of Washington has a strong and growing group of faculty and graduate researchers in HCI and ubicomp who will help guide my work. I am confident that in this dedicated and collaborative atmosphere, I will be able to accomplish my goals.

The broader impact of a unifying ubicomp framework is its ability to bring computer science out of the lab, and into the real world. In the same way that NASA's Apollo program inspired a generation of scientists, the ability to develop new tools in this framework will reinvigorate interest in computer science. The idea of a smart yet invisible room will have inherent appeal to many who experience the power of this idea in their homes and classrooms.

I can even use this idea to directly impact end users. Low-cost starter kits, based on my framework and containing sensors and software, could start an unpredictable number of hacks on this technology. These kits could be the LEGOs of a generation, allowing scientists of all ages to build their own systems.

The problems in ubicomp are among the hardest to solve because they involve an understanding of multiple areas. Without insight into how to build an integrated framework that addresses the core issues in creating ubicomp systems, we will be forced to keep the awkwardly coupled applications we have today – falling one step short of Weiser's exciting vision of seamless and pervasive computing.

[1] Weiser, M. The Computer of the 21st Century. Scientific American, 1991, 265 (3), pp. 66-75.
[2] Rafael Ballagas, Meredith Ringel, Maureen Stone, Jan Borchers, iStuff: A Physical User Interface Toolkit for Ubiquitous Computing Environments. *CHI 2003*
[3] Martin Modahl, Bikash Agarwalla, T. Scott Saponas, Gregory Abowd, Umakishore Ramachandran. "Towards a Standard Ubiquitous Computing Framework." *MPAC' 04*
[4] Intel Mote http://www.intel.com/research/exploratory/motes.htm
[5] Anind K. Dey and Gregory D. Abowd. The Context Toolkit: Aiding the Development of Context-Aware Applications. http://www.cc.gatech.edu/fce/contexttoolkit/pubs/SEWPC00.pdf