RESEARCH PLAN

Motivation and Background:

For the past two years, our team has successfully established a digital-healthcare platform including building block technologies (sensor nodes, sensor networking, indoor localization, activity recognition, computer vision technology, etc.) as well as digital healthcare applications developed on top of this platform (care wall, diet-aware table, emergency alarm, Get a sandal, smart lunch tray, etc.). In the upcoming year, based on the lessons we have learned from building these applications, we would like to enhance our digital healthcare platform and its technical building blocks. Again, our emphasis will be on creating real, working technology that can be demonstrated.

The objective for this project is to create a platform that can enable the next generation e-services for digital living at home. We believe that the driving force for the next generation e-services for digital living should come from awareness technologies that recognize and understand how we as humans live in our physical home environment, rather than relying on creativity or innovations of a few brilliant service vendors. In other words, we believe in the Web 2.0 approach and its principles on “Harnessing Collective Intelligence” and “Data is the Next Intel Inside”. That is, intelligence for the next generation digital living e-Service comes from collecting and analyzing potentially massive amount of data detailing every moment of our physical living. In another perspective, this is about going back to the basics: “more (physical living) data is more intelligence for the (digital living) e-services”. Therefore, the main technical theme for this project is on scalability, leading to the following technical challenge.

- How do we scale up our system infrastructure to be able to collect and process potentially huge amounts of physical living data coming from a variety of sensors at home (e.g., from cameras, microphones, wearable biometric sensors, laser scanners, touch sensors, RFID sensors, etc.)?

We believe that most of the services for digital living, such as digital healthcare, home automation, home energy and water conversation, home media and entertainment services, etc., will benefit from this research work – understanding human needs (i.e., their physical living) is fundamental in improving their (digital living) services.

Significance

This proposal fits into Intel’s digital health vision where we can extend the PC and embedded processor penetration into the households; therefore creating a new potential market for Intel-based PCs, embedded processors, and communication products. In addition, this proposed project is pushing for “scalability” in the hardware computing and communications infrastructure at home, which can generate even a higher demand for Intel-based PC, embedded processor, and communication products.

Scalable Digital Health Framework

Our premise in this project is to (1) create a scalable system framework with key enabling technology building blocks in multi-modal sensing wireless sensor networking, scalable wireless sensor network, scalable living data collection and processing, and scalable information service; and (2) prototype several real working applications using this platform.

This integrated system framework is shown in Figure 1. The closest to hardware (or called the first) layer is the scalable multi-modal sensor and sensing layer. It is consisted of different types of sensors deployed on the human body (wearable sensors), installed and fixed at home (infrastructure sensors and location sensors), and on a moving robot (mobile sensors). Sensors and sensing are high competence area for this integrated research team given that many team members have accumulated lots of experiences in using and making different types of sensors in prototyping real working systems in the past. For example, we utilize wearable sensors include various types of biometric sensors, such as GSR (for measuring skin
and fourth (highest) layer is the information service platform. Its job is to improve the infrastructural scalability of our new in- 

dependent access control policies of his/her living data to ensure privacy and security. This layer also includes two technical components: (1) to develop a tool for measuring link quality in a wireless sensor network in both the spatial and temporal variations, and (2) to design new sensor network media access control (MAC) and routing protocols with provisions of quality of services (QoS) that can scale up to accommodate a wide variety of sensor data streams.

The third layer is the scalable living data repository and contextual processing engines. Their job is to take raw sensor data as its inputs, process and analyze the input raw data to infer high-level contextua-

dependent access control that enables the end-user to specify access control policies of his/her living data to e-

The fourth (highest) layer is the information service platform. Its job is to provide secure and selective access of the high-level contextual data to the e-Services based on the end-user’s preferences. This layer contains three technical components. The first component is the privacy and access control on the high-

Project Components.

We summarize the technical components in each of five subprojects as follows.

- Subproject #1 is the fourth layer “information service platform”, targeting three technology
components: privacy and access control, service recommendation, and equal-priced bidding system.

- Subproject #2 is about the second layer “scalable wireless sensor network”, focusing on two technology components: spatial and temporal link quality measurement and Quality of Services (QoS) MAC and routing protocols for wireless sensor networks.
- Subproject #3 is about a scalable indoor location system that can achieve centimeter positional accuracy, low infrastructural node density of energy efficiency (20 nodes per 100x100 square meters area), and good energy efficiency. Its specialized location sensors are in the first sensor layer, and its positioning engine is located in the third “contextual processing” layer.
- Subproject #4 is the third layer “contextual processing” that turns low-level living data into high-level living activities.
- Subproject #5 is the first “multi-modal sensor” layer, bringing both mobile robot and infrastructure sensors.

**Deliverables:**

The project deliverables are described as follows:

1. Some of the project results will be published in academic publications. All our academic publications will acknowledge the general grants from Intel.
2. We will submit quarterly reports to Intel disclosing our progress in this project. In addition, we will also submit a final year report summarizing final results.

We will prepare and be ready for a demonstration for the academic workshop of the IDF (Intel development forum) in April or October 2008. During the demonstration, we will showcase our scalable robot with hybrid sensor modules, a scalable indoor localization system, a scalable wearable biometric module, etc.

**A project timeline and measurement plan (1 page)**

The project is planned with quarterly milestones. We anticipate the prototype implementation to be completed by the 1st quarter and begin the initial integration between the closely-related components during the 2nd quarter. The 3rd quarter is dedicated to the preparation of the demonstrator to be showcased in IDF. With the feedback, we plan to refine the system using the remaining time in the last quarter.

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<td>II. Scalable radio interference localization system</td>
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<td>III. Wearable biometric sensor module</td>
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<td>IV. Scalable robot</td>
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BUDGET

- Personnel Expense
- Equipment Purchase
- Travel Expense
- University/Department Administration Overheads

Total: US$ 64,000

Figure 1. Scalable Digital Health Platform
Figure 2. Wearable Biometric Sensor Prototype.

Figure 3. NTU PAL-1 mobile robot wheelchair with a variety of sensor modules.
Figure 4. Radio interference sensor module (MICA2) for our scalable indoor location system.