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Demonstrating Micro-AMPS Technology Using Microphone Arrays
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This paper presents an M.Eng. thesis project to design and implement a system integrating the microphone array technology of the Intelligent Room with the wireless microsensor network of the Micro-AMPS project. Such a system would provide an excellent demonstration of the Micro-AMPS technology while creating a more versatile implementation of the Intelligent Room Project's microphone array. The following sections first describe the technologies involved, then give a description of the project. Following is a tentative timeline and a discussion of possible problems and solutions.

The Micro-AMPS project deals with micropower wireless sensor systems, which have many attractive properties for a wide range of applications, including security systems, medical monitoring, machine diagnosis, and chemical detection. The advantages of a distributed wireless micosensor network over a more traditional wired network with a small number of macrosensors include greatly improved fault tolerance, adaptability, and ease of deployment. The wireless microsensors can be easily distributed throughout the area of interest, and when powered up will organize themselves into a peer-to-peer network, with no need for central control.

The goal of the Micro-AMPS project is to develop a general-purpose framework for the implementation of an adaptive, power-aware, wireles distributed microsensor network. The project is not concerned with developement of the actual sensors, but

instead aims to construct a network of programmable nodes that can be fitted with a variety of existing sensors. The system can then be easily programmed to support a wide variety of applications. Key issues in this project include the need for low power and adaptive power-aware components, efficient communication over short-distance wireless channels, and effective collaboration in processing between the many nodes of the network.

Each Micro-AMPS node currently measures approximately two inches by two inches and contains a digital board for processing, an analog board for communications, and an optional base station allowing connection to a computer for additional processing and display of sensor data. The digital processing board contains an Intel StrongARM processor, memory, and an FPGA that handles the interface between the processor and the radio. The current state of the project consists of two functioning nodes that can communicate with each other in a laboratory setting, and the timeline currently calls for five to six nodes functioning as a network by Spring 2002. Given this timeline, an M.Eng. project starting Summer 2002 would be ideal for developing an application to run on top of the network, demostrating its capabilities.

The microphone array system used in the Intelligent Room project has the ability to detect and amplify sound coming from one particular location in a room, while filtering out other sounds such as background noise. The system can be used for applications such as intelligent videoconferencing, where a camera can track a speaker and direct the microphone array to focus only on the volume of space surrounding the speaker’s head.

Currently the microphone array is implemented as a fixed, wired system in a specially designed room at LCS. Implementing this technology using the Micro-AMPS hardware would allow for much greater flexibility. Instead of requiring a single, custom-setup room, one could potentially walk into any room with a box of Micro-AMPS nodes and a laptop and easily get a system up and running. In addition, the processing capabilities of the Micro-AMPS nodes could do a portion of the processing locally, cutting communications costs. The bulk of the project would be software development on the StrongARM, but some signal processing functions may be programmed in VHDL for speed. An important issue will involve designing the system to be adaptive to different node configurations. One advantage of having the sensors wired into a room is their positions are known and unchanging. Ideally after being integrated with the Micro-AMPs network the sensors would be able to dynamically determine their positions and adapt accordingly. Acheiving this goal and designing an effective method for the nodes to collaborate on data processing will provide two of the main technical challenges for the project.

I have recently begun a UROP with the Micro-AMPS project studying communications issues and designing a new encoding scheme to provide desired synchronization and error-correcting capabilities. I will continue this UROP over IAP and into the Spring semester, and during this time I will learn as much as I can about the different technologies involved in the project. Also, during the Spring semester I will finalize the details of my project and complete the thesis proposal. I will begin designing and building the system in Summer 2002, and work full time throughout the summer. Ideally I will finish the majority of the project by September or October, leaving time to

write the thesis and graduate in February of 2003. If this is not possible I will extend the timeline by a semester and graduate in June 2003.

The biggest risk is that the Micro-AMPS schedule may be delayed so there is not a functioning network at the time I need to begin my project. However, it should be fairly clear at least by the middle of Spring 2002 whether the project is likely to meet the schedule, allowing time to modify my proposal accordingly. If the network will not be complete by Summer 2002, I can change my project to one that will help to get the network working I am interested in networking software and protocols, and if the system is held up in this area I should be able to develop a project to help solve the problem.

Another risk is that the number of nodes available by Summer 2002 may not be sufficient to effectively operate a microphone array. The system currently in use at LCS contains 32 microphones, which is significanly more than the number of MicroAMPS nodes expected to be available. It may be acceptable for the purposes of this project to accept the reduced performance from a small array, provided the system is designed to be easily scalable to more nodes as they become available. Another possibility would be to use ordinary microphones as stand-ins for the missing Micro-AMPS nodes and simply route their data to the nearest node.

Integrating the microphone array technology with the wireless microsensor network will involve interesting challenges as an M.Eng. project, while providing a good demonstration of the capabilities of the Micro-AMPS project. It will also allow me to apply my interest in networking, communication, and signal processing to the design of a real-world system, providing a valuable experience and learning opportunity.