

2006 NASA EPSCoR Planning Grants

UNIVERSITY OF MAINE

Project title: Application of Wireless Sensors in Space Explorations

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Summary:

Today's society is getting closer to the dream of having reliable wireless communication any time and anywhere at a reasonable cost. The market is also driven by wireless networking solutions for data interrogation, identification, video, multimedia and tracking. These modern communications and networking possibilities are due to the advancement of wireless technologies in the past decade. As Marconi said "It is dangerous to put limits on wireless" and view wireless communications only as a tool for voice or data transfer. Significant recent research efforts in the area of wireless networks investigated the usage of low information capacity wireless nodes (also called "data acquisition points") working together to deliver information over a homogenous network. The common belief is that a multi-hop configuration with rather small per-hop distance is the only viable energy efficient option for wireless networks.

This proposal seeks to demonstrate that a single hop configuration, utilizing the asymmetry between low complexity wireless nodes and a more powerful super-node can actually have lower overall power consumption than a multi-hop counterpart. In addition, the proposed new paradigm for wireless communication combines the use of low complexity and more powerful super-nodes to allow deployment of high performance codes required to achieve channel capacity. This planning proposal aims to prove the feasibility of the proposed system through both hardware and software implementations and strengthen the concept to be competitive for the 2006 NASA EPSCoR competition. This will be done through design and implementation of the proposed system in a simulation environment and collect enough data from both hardware and software to support the theoretical claims. The simulations will be validated through fabrication of micro-sensors and collection of experimental data. Upon successful completion of this planning effort, a more generalized framework will be considered for the NASA EPSCoR competition which includes a larger number of micro-sensors to address the scalability and network management issues. The required equipment and parts of student salaries will be supported through matching funds from the University of Maine Vice-President for Research and the Department of Electrical and Computer Engineering. The requested funding will be used towards graduate/undergraduate student support, material for device fabrication, system implementation and data collection.

In addition to the technical objectives mentioned above, this planning proposal will be instrumental in strengthening our relationship with the NASA Johnson Space center (JSC) in Houston, TX and align our project with their missions. NASA JSC is recited by the preliminary interactions with the PI's group under seed grant effort. The wireless sensor network research group at JSC under direction of Dr. Pat Finck will be the major NASA contact and collaborator on this project. The reliable communications link and reduced power consumption architecture designed in this project will impact both space shuttle monitoring systems and facilitates space exploration by enabling new technologies for practical use of wireless sensor networks. More details on the specifics of this project will be revealed during our collaboration with JSC under this planning proposal.

Intellectual Merit - A hybrid communication architecture implemented through a two-tiered wireless network is proposed. This novel scheme employs super-nodes in an analogy to leaders in our society. The super nodes possess more resources and are able to handle computationally complex tasks. This architecture will enable the use of more efficient error correction schemes such as Turbo-codes or Low Density Parity Check (LDPC) codes which are capable of achieving channel capacity. The two-tiered wireless network concepts will be verified through the implementation of a spread spectrum passive wireless data acquisition system. A significant technical merit of the proposed scheme resides in achieving channel capacity by distributing the error correction scheme into different hybrid architecture tiers. By doing so, very efficient error rate reduction techniques in wireless communication links will be implemented, also allowing low power consumption at the data acquisition wireless communication tier. The lower tier will acquire information from distributed individually labeled wireless passive sources. These sources will be implemented using pseudo random codes photo-lithographically printed in surface acoustic wave matched filters for a direct sequence spread spectrum system. The implementation of code division multiplexing in the lower tier will allow the usage of the same spectrum and high isolation between orthogonal codes.

Broader Impact - Both PIs will actively advise graduate and undergraduate students involved in this project and administer weekly meetings and monthly reports to direct the project efficiently. The PIs' ongoing participation in the NSF funded REU, RET, GK-12, IGERT program at University of Maine will be continued and further enhanced by this planning proposal. The project will therefore address the State of Maine Science and Technology educational targets of exposing high school students and teachers to the cutting edge research in wireless communications. The targeted full EPSCoR proposal will enable us to provide local high school students with hands-on experiments with tiny wireless radios that can be programmed to monitor different environmental parameters and transmit to a base station. In addition to significantly increase the public interest in engineering education in the state, this type of effort also impacts the communications industry through PIs' participation at the Maine Telecommunications User Group (MTUG). The developed technology will impact the state's Connect-Maine initiative by providing low cost solutions to connect the whole state with wireless technology both for monitoring purposes and broadband wireless access for rural areas with no cable or DSL. The PI contacts with Mainely Wired, a Maine based communication

company, has exposed the pressing need for students trained in the wireless technologies to expand their operations throughout the state of Maine.

The research results, including both raw data and publications, will be posted on a web site specifically designed for this project. The PIs prior experience to organize workshops and conferences (PI is the Chair for IEEE Communications and Computer Societies joint chapter, and served as general chair of the 2006 IEEE Student Conference; and Co-PI is Technical Chair of the 2007 IEEE Ultrasonic Symposium) will be used to disseminate the knowledge gained with this project to the research community and also bring recent progresses in the field to the University of Maine by inviting distinguished lecturers and promoting workshops.