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**Final Report for DOD Grant DAAG55-98-1-0329  
(ARO #38135-EL-RI)**

**Instrumentation to Support Research in Wireless  
Spread-Spectrum Communications**

Final Report

by

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Jan. 15, 2002

U.S. Army Research Office  
Office of Naval Research

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This is a brief report summarizing the equipment purchases and resulting research activities that have benefited from the DoD equipment Grant DAAG55-98-1-0329 entitled "Instrumentation to Support Research in Wireless Spread-Spectrum Communications." The various items purchased under this instrumentation grant and their costs are itemized under the List of Purchases, found at the end of this report.

The grant has established new research capabilities and significantly enhanced the quality of existing research facilities in wireless communications in the Department of Electrical and Computer Engineering at Clemson University. The equipment has enabled faculty and graduate students to carry out advanced computer-aided design and analysis for military communication systems and networks. It has enhanced research conducted on a number of DOD-funded research grants and has played a critical role in a variety of publications that have resulted from this research.

The equipment consists of special-purpose computer equipment (6 high-speed UltraSparc workstations) and supporting peripheral hardware. The systems were used in conjunction with a specialized software package, Signal Processing Worksystem (SPW), that facilitates the simulation of spread-spectrum communication links.

A major thrust of the wireless communications group at Clemson has been research on wireless, mobile, distributed multimedia communication networks. This work, largely funded by DOD research grants, encompassed a broad research activity in wireless, distributed mobile networks that provide multimedia communications in hostile electromagnetic environments. Em-

phases included adaptation to changes in interference and propagation conditions, interaction between the network protocols and the communication system, and provisions for internetworking of multimedia traffic. Developments included protocols for wireless networks, advances in spread-spectrum signaling and error-control coding, techniques for wireless multimedia communications, and adaptive data modulation techniques for radio channels. Routing protocols tailored to multimedia traffic, the use of error-control coding to aid adaptive network protocols, multimedia access in local area wireless networks, and interconnections among tactical radio networks and wide area networks, are among the innovations of this research that directly benefited from the instrumentation provided through this equipment grant.

Research was also conducted on signaling schemes and error-control coding schemes specifically designed to convey multimedia information. Novel algorithms for demodulation based on pattern-recognition techniques were also developed. Such algorithms were shown to provide demodulation performance better than symbol-by-symbol techniques without the complexity of optimal block detection techniques.

Research on the effects of multipath propagation on the performance of DS systems was also conducted. The research was focused on characterizing the direct sequence (DS) signal at the receiver in a multipath channel and evaluating the effects of system design choices on the performance of the system. Particular emphases include the DS signal design, coding and interleaving, link protocols such as power control and channel access, and receiver signal-processing techniques.

Research was also conducted on the development of improved techniques for multipath acquisition and multipath combining. Among the issues under investigation were the need for periodic retraining of the multipath combiner tap settings during reception of a packet and the robustness of coherent combining schemes and phase tracking procedures in time-varying channels. In addition, highly effective single-stage and two-stage acquisition algorithms were developed for acquisition of primary and secondary multipath components.

Additional research focused on the development of adaptive network protocols for robust, high-throughput direct-sequence packet radio networks. Novel techniques for obtaining side information extracted from the lower protocol layers were developed. Among the transmission parameters investigated for adaptation were the information rate, error-control coding rate, power level, and packet length. Adaptive forwarding, routing, and retransmission protocols were also investigated.

Research has also focused on error-control coding and receiver processing methods for frequency-hop systems. In particular, the research has focused on slow frequency-hop spread-spectrum radios which must operate in the presence of multiple-access interference, partial-band interference, and frequency-selective fading. Improved coding and decoding methods have been shown to increase throughput and decrease bit and packet error probabilities without increasing bandwidth requirements.

LIST OF PURCHASES

Item	Qty	Equipment	Unit Cost	Charge to Grant
1	4	Sun Ultra 10 300 MHz workstation 300 MHz, 64MB RAM 4.3GB disk, Creator 3D Graphics 19 inch Monitor Sun Microsystems, Inc.	4,095.00	16,380.00
2	5	Memory expansion 128MB 2 DMMS Sun Microsystems, Inc.	826.50	4132.50
3	2	Sun Ultra 60 Model 2360 2 × 360 MHz UltraSparc-II 256 MB, 9 GB disk, 3d Graphics Sun Microsystems, Inc.	18,156.90	*25,040.64
4	1	Internal CD-ROM Drive Sun Microsystems, Inc.	180.00	180.00
5	6	Video Connector Adapters Sun Microsystems, Inc.	30.45	182.70
6	5	Back-UPS 650 Mac Warehouse	229.99	1149.95
		Subtotal		47,065.79
		Tax		1,867.21
		Shipping		†0.00
		TOTAL		48,933.00

Matching funds have paid for one additional item 1 (\$4095.00), one additional item 6 (\$229.99), tax (\$259.49), shipping (\$4.95), and additional computer supplies (\$359.57). Total value of match commitment: \$4949.00

\*Charges shared with another funding source. The two were purchased separately.

†Sun Microsystems did not charge shipping; Mac Warehouse shipping charges were covered with matching funds.