Title: **ZebraNet: Position-aware power-aware wireless computing for wildlife tracking**

Start Date: September 1, 2002
Expires: August 31, 2005 (Estimated)

Investigator: **Margaret Martonosi** martonosi@princeton.edu (Principal Investigator)
Harold V. Poor (Co-Principal Investigator)
Daniel I. Rubenstein (Co-Principal Investigator)

Sponsor: Princeton University, Princeton, NJ 08544 609/452-3000

Abstract: As computer systems become increasingly ubiquitous, computer systems research and design has moved from being a highly performance-centric process to being one that juggles many design goals and metrics. Mobile and embedded computing systems must, in addition to providing sufficient performance, be rugged, reliable, power-efficient, and lightweight. Because of the extreme and multidimensional design constraints they face, they must also be attentive to the specific needs of application domains, so they can be designed to satisfy these needs while still meeting power budgets and weight limits.

The Princeton ZebraNet Project is an inter-disciplinary effort with thrusts in both Biology and Computer Systems. On the computer systems side, ZebraNet is studying power-aware, position-aware computing/communication systems. Namely, the ZebraNet project works to develop, evaluate, implement, and test systems that integrate computing, wireless communication, and non-volatile storage along with global positioning systems (GPS) and other sensors. On the biology side, the technology enables novel studies of animal migrations and inter-species interactions. From a computing standpoint, key research breakthroughs are required in protocol and system design in order to make the system power-efficient and reliable. From a biology standpoint, the system enables fundamentally new types of biological observations that allow us to: (i) understand long-range migrations in large mammals, (ii) observe inter-species interactions between carnivores (predators) and ungulates (prey), and (iii) track the behavior of extremely endangered species.

As a computer systems research problem, ZebraNet is compelling because the needs of the biological researchers are stringent enough to require real breakthroughs in wireless protocols and in low-power computer systems design and computer systems power management. These breakthroughs can be leveraged into other (non-wildlife-oriented) fields of research; essentially ZebraNet is a power-aware wireless ad hoc sensor network, but with more serious bandwidth and computational needs than most prior sensor networks research problems. As a biology research problem, ZebraNet allows researchers to pose and to answer important long-standing questions about long-range migration, inter-species interactions, and nocturnal behavior.

Major research activities span a broad range, including: Modeling long-range animal migrations Observing inter-species predator-prey interactions Analyzing the impact of human development on animal behavior Developing power-aware systems for position-aware computing Incorporating error resilience and domain-specific performance optimizations into lightweight wireless protocols Managing logged sensor data to minimize the number of required uploads from tracking nodes

ZebraNet is engaging in a mix of theoretical research, prototyping, and field experimentation. The project is not solely about systems-building, but rather mixes theory with practical hands-on evaluations of the ZebraNet designs. Research is conducted both at Princeton University and at the Mpala Research Centre. Mpala is a biology field station in central Kenya that Princeton University administers along with the Kenya Wildlife Service, the National Museums of Kenya, the Mpala Wildlife Foundation, and the Smithsonian Institution.

Overall, ZebraNet represents a truly interdisciplinary effort bringing together research strengths from disparate fields over a challenging problem. The potential contribution of the project includes significant advances in computing technology as well as in our understanding of wildlife migrations. The three main researchers bring strengths in wildlife biology, power-aware computer systems, and wireless technology. The interplay between these disciplines fosters creative to the research problems in both arenas.