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Networked Infomechanical Systems: A Mobile Embedded Networked Sensor Platform

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Rapidly growing stress on the natural environment has created an urgent demand for new environmental exploration systems that operate remotely and autonomously. As sensor networks are applied to this critical environmental monitoring problems, a series of new requirements have emerged for extensive characterization of dynamic phenomena in three-dimensional environments. The unpredictable presence of obstacles to sensing and the inherent temporal evolution of events create limitations for optimal deployment of sensors in the environment. Networked Infomechanical Systems (NIMS) technology has been developed to introduce precise and sustainable actuation for distributed sensing. Figure 1 schematically shows mobile and static NIMS node architectures. NIMS devices are suspended on cable infrastructure to provide a combination of broad range motion combined with accurate localization. Elevated infrastructure also provides energy harvesting capability as well as energy delivery to suspended nodes. NIMS embedded sensor nodes may move, acquire sensor samples, collect images from diverse perspectives, and also acquire physical gas phase and liquid samples. NIMS systems have been deployed in the natural environment and through their architecture, dramatically reduced the problems of limited sampling density that has confronted fixed sensors.

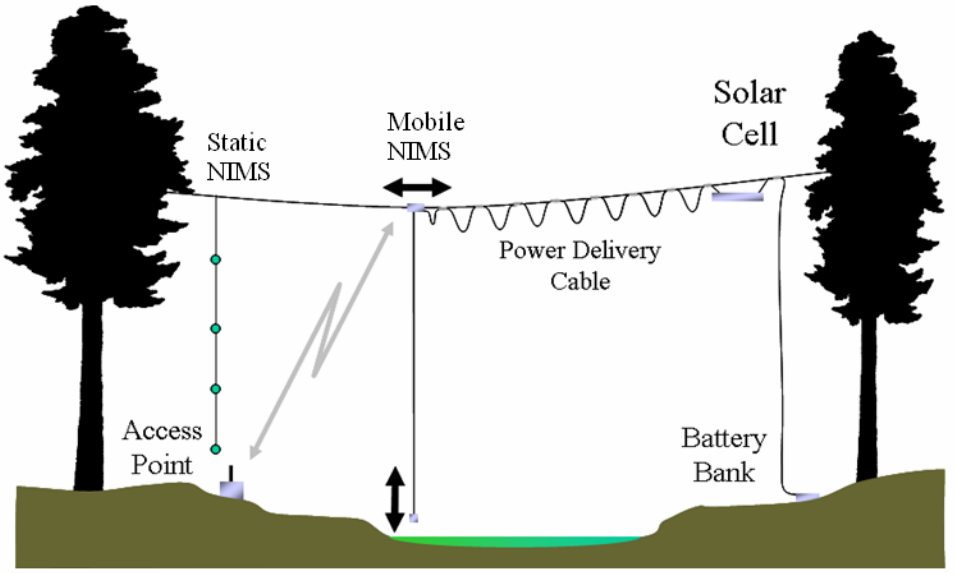

Figure 1. Mobile and Static NIMS Node architectures are shown in schematic view, deployed in a forest environment for microclimate and water system monitoring.

NIMS nodes are based on a multiprocessor architecture that combines modules dedicated to sensing, imaging actuation, and power control. Embedded node software systems rely on the

EmStar development and runtime environment. The requirements for adaptive sampling and other applications have further stimulated the development of statistical computing based on the R language. The R environment is hosted on the embedded NIMS node systems and R modules have developed for control of actuation and sampling.

NIMS system also includes a network of sparsely distributed, suspended fixed sensors (referred to as "sensor strands"). These NIMS fixed devices provide event detection capability, guiding NIMS mobile devices to most efficiently detect and track dynamic field conditions according to task allocation methods. NIMS systems are being adopted by several application communities. First, at the James San Jacinto Mountain reserve, as shown in Figure 2, NIMS Field systems are in use for microclimate and solar radiation mapping. NIMS RD (Rapidly Deployable) is being applied by Public Health researchers for measurement of water quality and contamination in the Los Angeles area watershed. NIMS systems are also under development for deployment in the Merced River for characterization of the influence of agricultural processes on river water quality. Finally, NIMS LS (Laboratory System) has been applied in indoor deployments for system verification, training, and education.

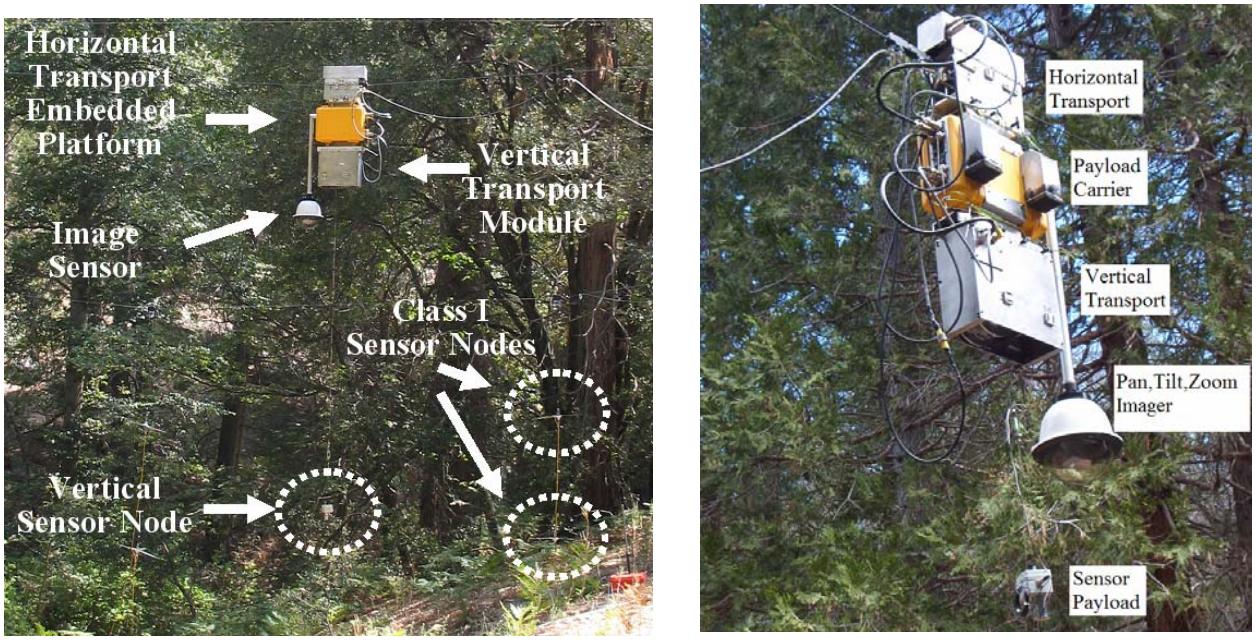

Figure 2. (a) NIMS Node deployment at the James San Jacinto Mountain Reserve. (b) NIMS node detailed view.

NIMS will be demonstrated through real-time remote access to remote NIMS nodes operating in two locations. One location will be the James San Jacinto Mountain reserve. This will include a demonstration of new NIMS multiscale sensing systems that combine imaging and sensing to map dynamic phenomena. The second remote location will be to a deployment of NIMS LS where experiments in adaptive sampling will be demonstrated. Visitors to this demonstration will view live data and observe NIMS node mobile operation. A large format video display will be arranged. Posters will also be supplied. Finally, NIMS operating, networked node hardware will also be displayed, demonstrating distributed EmStar access to node and sensor resources.