CPS: Medium: Self-Sustaining CPS for Structural Monitoring

The American Society of Civil Engineers' recent report on US infrastructure estimates that a $2.2 trillion investment would be needed to bring them up to par. An estimated 30% of the nation's 10,000 steel railroad bridges and 600,000 highway bridges are either structurally deficient or functionally obsolete or both. Currently, most bridge inspections are visual only, which has been shown to be ineffective in identifying problems. Acoustic Emission (AE) testing is a comprehensive and effective way of detecting structural damage. However, current AE measurement systems - requiring high sampling rate and fast signal processing - are based on wired and centralized data collection which is labor intensive and expensive. There is an urgent need for a cost-effective system that is able to continuously and autonomously monitor the structural health of bridges.

The goal of the project is to design, prototype and experimentally verify a self sustaining, autonomous, wireless structural monitoring system based on stress, vibration and acoustic emission sensing. At the core of our research effort is a low-power **Flash FPGA-based hardware platform**, which offers a radically new approach to CPS design. Critical parts of key algorithms and system components can be implemented in hardware for increased performance while the Flash-based technology enables effective duty cycling - a proven approach for low-power design in sensor networks.

Energy harvesting is based on a novel **vibration-based** experimental technology that works with a broad range of excitation frequencies. The **harvester** automatically adjusts its resonant response to that of the bridge component, in order to capture more energy than a fixed resonant frequency harvester, such as the most commonly used piezoelectric transducers, can.

Structural health assessment involves quantitative analysis of AE signals to determine crack type, location, orientation and size as well as component-level and system-level health assessment fusing all available sensor data. Laboratory experiments and field tests on actual bridges are carried out to validate key aspects of the new research platform.