Introduction

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SHM or Structural health monitoring involves detecting changes to the geometrical properties of a structure. These changes gradually result in permanent damage or even collapse of structures. To measure the changes that the structures have undergone, array of sensors are normally used. These sensors collect the response of structures under various conditions. The data thus collected is statistically analyzed. This analysis helps engineers to determine the health of the given structure. Traditionally wires are used to collect readings from a array of sensors. Such a mechanism to observe the structural health parameters, often involve complex, costly and bulky electronic hardware.

A wireless sensor network replaces the usage of such a complex system. The main advantages of such an approach are that there is enormous reduction in cost, size and power requirements for a sensing system. As the communication is over wireless channels, laying and maintaining cumbersome wires is not needed.

WSN For SHM

Functionally Wireless sensor platforms invariably comprises of a sensing front end to sense the physical phenomena one wishes to observe, an analog to digital convertor to convert this observed signal (in analog domain) to digital domain, a micro controller to do basic processing of this digital data and a radio front end to modulate and transfer this digital data through wireless channels to another similar hardware or a computing node for further processing.

These WSN platforms usually come as a single piece of hardware, often resulting in scalability and reusability issues.

Our idea was to introduce modularity in the design approach, so that depending on the needs of the application one can change the necessary part of the system.

Usually the WSN hardware and end applications use an operating system. We realized that the purpose of O.S must be justified from the end application point of view.

Our application involved sensing the acceleration and the strain, time stamping and assembling them to send it through the radio interface to a head end PC. This head end PC would again sort the acceleration and strain data and securely transfer it to a distant node 100s of kilometers. A 2G/3G mobile data card is used to do this final transfer.

The software required for sorting, assembling and time stamping the sensor readings in the micro controller are written in simple C routines. The software for the radio communication protocol between the WSN node and the head end is vendor provided. The software for sorting the incoming packets from the WSN node and sorting them in to two different files is written in perl scripts.

Our mote has (1) sensor components (an Accelerometer (MMA8452Q) and an Wheatstone bridge) in our case, (2) an Amplifier component (LMP8358), (3) an ADC component (ADC161S626) (4) a microcontroller (the ARM based LPC 1347) in our case, and, (5) a radio component (CC2530 in our case).

The above is divided into four boards, namely, the sensor board which has components (1), (2) and (3) above, the processor board, the radio board and the power board.

This division is interesting so that one can replace any one of the components with latest ones without affecting the design of other boards.

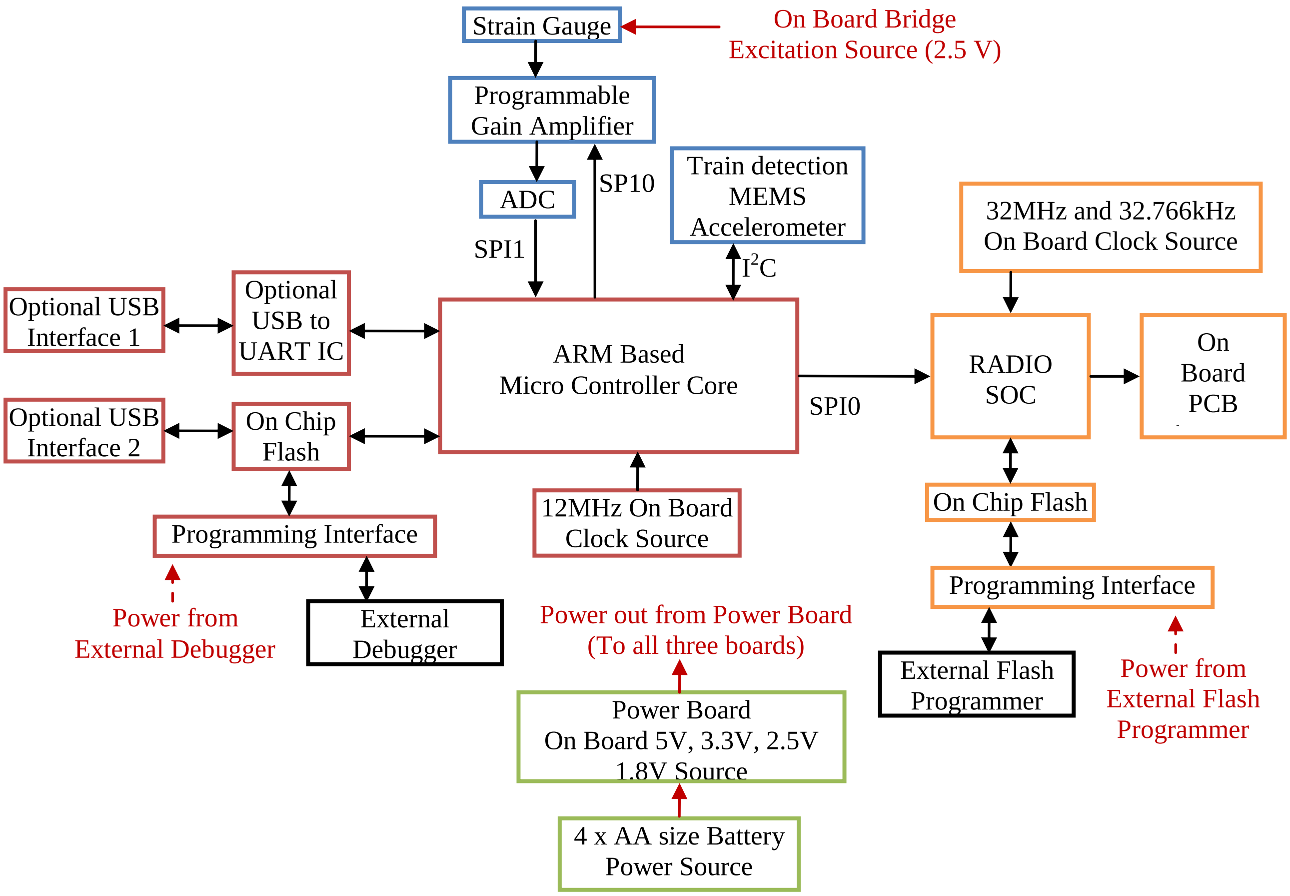
An independent power board that supplies power to these boards can be modified to suit any changes without affecting the unchanged components. In this way, the current design is flexible.

The ADC used is a 16-bit ADC capable of 50000 samples per second at 1 Mhz frequency.

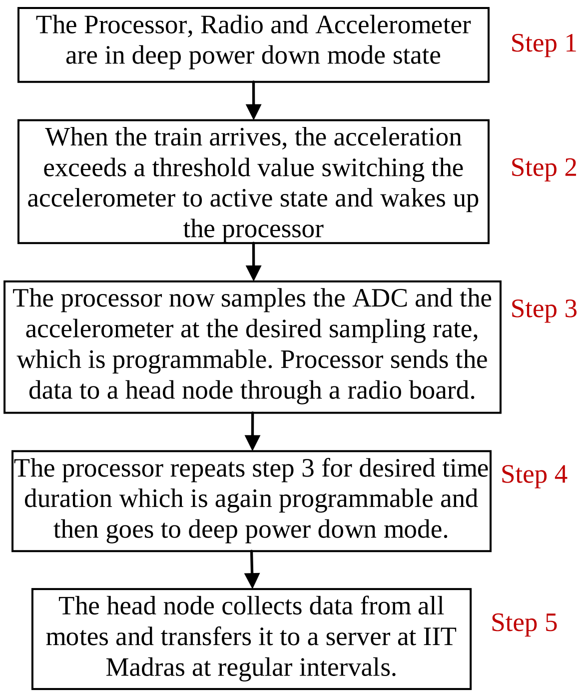
In our application the need is 500 samples per second. The LPC microcontroller is versatile from the peripheral interface point of view as it supports two Serial Peripheral interfaces (SPI) and one Inter integrated circuit I^2C interface.

The Amplifier and the Radio are connected on the SPI0 interface, the ADC is connected using the SPI1 interface, while the accelerometer is connected using the I^2C interface.

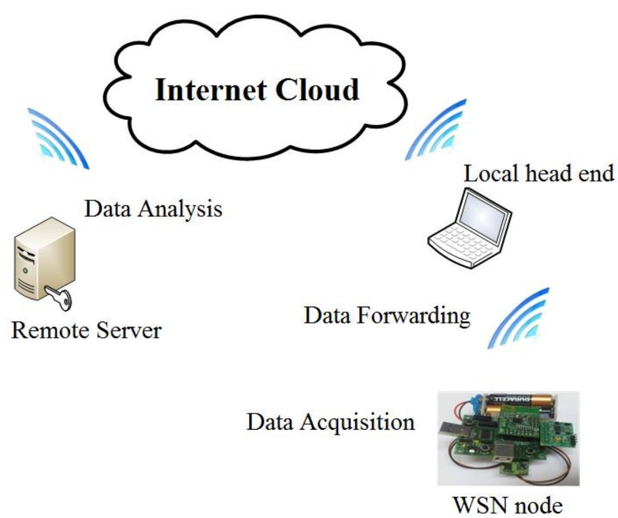
The following figure shows the hardware architecture and functional flow of our WSN system.



The following figure shows the functional flow of the entire solution



The following figures shows the sample deployment scenario



The following figure shows the deployed strain sensor on a railway bridge: