Development of Micro Wireless Sensor Platforms for Collecting Data of Passenger-Freight Interactions

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Project Objective

Traditionally, pavement inductive loop sensors are used to collect real time traffic data for passenger-freight movement in roadways. This method, however, is expensive to install and maintain, and also requires an electronic control unit connected to the induction loop. In the last decade, significant improvements have been achieved in Micro-Electro-Mechanical System (MEMS) sensors domain with respect to size, cost and accuracy. Due to process miniaturization and low power consumption, these "sensor nodes" can potentially remain functional years. Motivated by these novel advances, we propose a wireless MEMS sensor based passenger-freight interaction detection framework for Intelligent Transportation Systems (ITS).

Problem Statement

Traditionally, pavement inductive loop sensors are used to collect real time traffic data for passenger-freight movement in roadways. This method, however, is expensive to install and maintain. It requires significant cutting into the road for the inductive loop and also requires an electronic control unit that is connected to the induction loop. Our proposed system is mainly composed of two sub parts. Firstly, the sensor motes with possible energy scavenging privilege which contain Magneto-Resistive (MR) sensors to detect passenger-freight vehicles. Secondly, an Electronic Control Unit (ECU) which collects traffic data from sensor motes to calculate speed, length, volume and traffic congestion. The ECU contains RF transceiver to communicate with sensor motes and a GPRS (General Packet Radio Service) shield to send aggregated traffic data to the county or regional traffic data collection center. Our proposed solution will be significantly cost effective in comparison to traditional induction loop approach and it is scalable to cover millions miles of roadways all over the US.

Research Methodology

A high level system architecture of our proposed method is shown in Figure 1. The system is composed of sensor nodes which will be implanted in the pavement of road. Each node will be equipped with lithium battery and also will have electro-mechanical energy scavenging component (pressure and vibration). Hence a sensor node will be operational years without the need for changing battery. In each lane, two sensor nodes will be implanted to detect vehicle presence, speed, and type. Each sensor node will be "wirelessly" connected with an Electronics Communication Unit (ECU) in a "star" networking topology. The ECU will be an on-site controller and perform traffic data aggregation from the deployed sensor nodes. It will be powered mainly from photovoltaic (solar) cells and will have also standby compact battery. If direct power supply is available in the spot then it could be also connected to AC power line. The ECU will assign a TDMA (Time Division Multiple Access) time slot to each node and each node will send traffic data to ECU in the assigned schedule. TDMA protocols are proven to be very energy efficient for resource-constrained embedded wireless sensor networks. Whenever a sensor node detects any vehicle event (*approach* or *departure*), it reports the event to the ECU node through the pre-assigned TDMA slot. When the ECU receives the traffic event packets from the sensors, it checks the timestamp for each event packet and then stores it locally. After certain interval, ECU transmits aggregated traffic data to the regional/county wide data center.

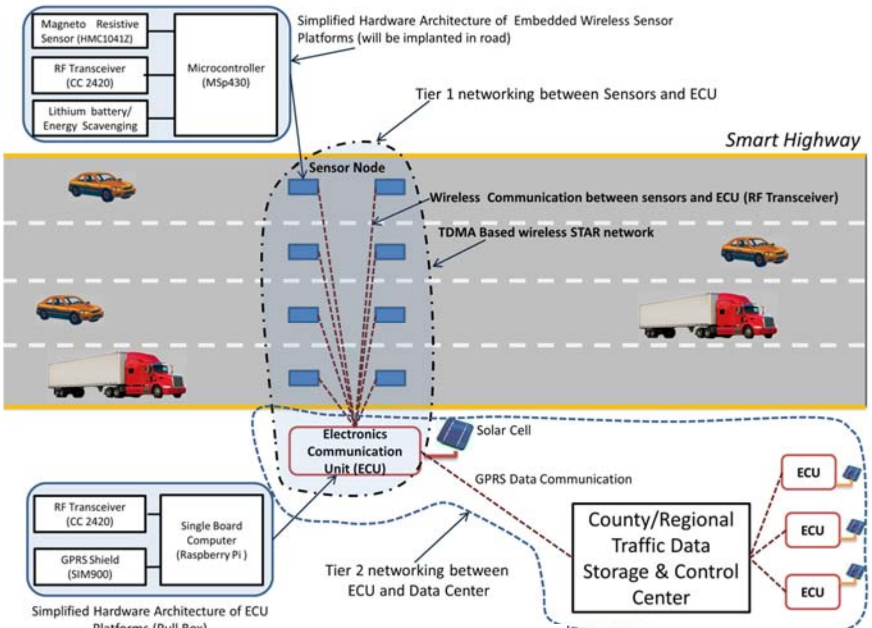

Figure 1 Proposed Architecture

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Outcome

Utilizing machine learning algorithm, we developed a system that utilizes the accuracy given by the resultant model to create a highly efficient sensor node. This node includes a microprocessor (CC430), an AMR sensor (HMC5883L) communicating through i2c, and an antenna needed to transmit and receive data. The firmware is written in C using TI's Code Composer Studio suite. Our developed prototype sensor node has a form factor of 30mm x 30mm or roughly the size of a quarter. This prototype is built for button cell battery operation in mind. However, with long-term operation, the depth and volume of the unit will change depending on the size of the battery. This sensor alone is sufficient enough to detect, classify vehicles, and transmit or receive data between itself and the ECU or another sensor in the network. Furthermore, with the built in transceiver, the sensor node can also act as a simple ECU receiver as well. This sensor can output data through Serial UART and any application that can parse the serial data such as MATLAB can easily use the sensor information to calculate speed and congestion through the use of multiple sensors. However, with more complicated designs where more computational power needed, a larger, more powerful ECU with a stronger microprocessor may be necessary for niche applications.