Poster Abstract: Using Mobile Wireless Sensors for In-situ Tracking of Debris Flows
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Abstract
Most debris flow monitoring systems deployed today use indirect means to track information regarding debris flows. In this work, we introduce a novel debris flow monitoring system for in-situ and direct tracking of debris flows in real-time. The core idea is to throw wireless sensors into the debris flows and collect flow information as they move along. We will describe the design of the wireless sensors and present some preliminary performance results.

Categories and Subject Descriptors
C.3 [Special-Purpose and Application-Based Systems]: Real-time and Embedded Systems

General Terms
Measurement, Performance, Design, Experimentation, Verification.

Keywords: Debris Flow Monitoring, Wireless Sensor Networks, Deployment, Mobility, Real-time.

1. Introduction
Debris flow is a type of fast moving landslide mixed with mud, water, and boulders. It destroys everything in its path and causes great damages to the inhabitants and their properties. A number of sensing devices have been used to monitor debris flows and track their parameters [1][2][3], in hope for early warning and prevention. However, current deployments can only provide point and indirect measurements. For example, the trip wire sensor is often used to detect the front of debris flows on wire breakage. It only detects the presence of debris flows, but not parameters such as speed, volume, and density. Similarly sensors such as rain gauges, geophones, and CCD cameras are often installed on the riverbank and provide only indirect measurements of the debris flows. Besides, they can only provide information of the debris flows within their sensing range.

If we can deploy sensors directly into the debris flows, many important parameters may be obtained continuously and directly. What are required are measuring devices that are very rugged and will move with debris flows but not with clear water. More importantly, they need to transmit the collected information back to the base stations in real-time. This not only ensures that occurrences of debris flows can be detected and warnings can be issued in time, but also collects debris flow information as much as possible in the base stations lest the sensors may fail.

In this paper, we introduce a novel debris flow monitoring system for in-situ and direct tracking of debris flows in real-time. The core idea is to throw wireless sensors into the debris flows and collect flow information as they move along. We will first present the system design of the wireless sensors, which is followed by our communication scheme. Preliminary performance results of our design are presented next and future plan of our research are given.

2. System Design and Implementation
Figure 1 shows our system design. There are two types of devices: INSIDER and COORDINATOR. INSIDER is a mobile wireless sensor with rugged plastic housing (see Figure 2). It will be deployed to sit on the riverbed and stay stationary in water. When debris flows come, it will float and move along with the flow.

INSIDER is based on the Texas Instrument MSP430F1611 low-power microprocessor and Chipcon CC2420 radio transceiver with a 3-dBi Omni-directional antenna. In order to sense the vibration generated by debris flows, we integrate Analog Device ADXL330, a low power 3-axis MEMs accelerometer. By analyzing the vibration information, we will be able to deduce parameters such as the time the debris flow occurs, the speed and direction, the force inside the debris flows, etc.

INSIDER is equipped a pair of AA size, 2500 mAh Ni-Mh rechargeable battery, which supports INSIDER to work in standby mode up to 30 days without charging. A 5x5 cm mono-crystalline silicon solar panel is integrated on the top of INSIDER to provide up to 70 mA to charge the battery on sunny days. The shape of INSIDER is streamlined so that water resistance is minimized.

Figure 1: System overview
3. **Low-Power, Time-Division Communication**

INSIDER is designed to stand by for several months. Thus, minimizing the energy consumption is critical to prolong the lifetime of INSIDERs. In our system, COORDINATORs manage Standby Communication Schedule (SCS) and Active Communication Schedule (ACS) of INSIDERs in different working modes. In the standby mode, INSIDER continuously samples the vibration and reports its statistics while the radio transceiver is enabled. INSIDER bases on SCS to power on the radio transceiver for the first 0.5 seconds and turn off for the remaining 5.5 seconds in every 6-second schedule cycle.

The average current drawn in the standby mode is only 2.8 mA, because the radio transceiver is disabled at most time. Once INSIDER is triggered by significant vibration from debris flows, it changes to the active mode. In this mode, it keeps sampling vibration and transferring the data to COORDINATOR according to ACS. ACS is a time-division communication schedule for the active mode. Each INSIDER managed by a COORDINATOR is assigned an exclusive time slot in ACS, in which it can transmit data without radio contention from other INSIDERs. It is noted that in our work clear channel assessment (CCA) is enabled to increase the package delivery ratio.

4. **Preliminary Results and Future Works**

We evaluate the communication performance of our system. Six INSIDERs are set on the ground in a grid pattern as shown in Figure 3. The distance between the INSIDERs is 6 meters. COORDINATOR is placed from the No. 1 INSIDER at a distance of 20 to 30 meters. All INSIDERs simultaneously send 150 Hz vibration data based on the ACS assigned by COORDINATOR. The experiments show that the package delivery ratio is around 99% when the distance is less than 25 meters. We also test the communication performance of INSIDER moving at a velocity of 4 and 6 meters per second. The distance from COORDINATOR to INSIDER is 35 meters. The result shows that the package delivery ratio is around 95%, which is sufficient for post-analysis in the backend server. After we perform more tests in the next few months, we will deploy this monitoring system at the Shen-Mu village in middle of Taiwan in 2009. The location is a frequent debris flow hazardous area.

5. **Acknowledgment**

The authors acknowledge supports from the National Science Council, Taiwan (R.O.C.), under grant NSC 96-2218-E-007-009, the Ministry of Economic Affairs, Taiwan (R.O.C.), under grants 96-EC-17-A-04-S1-044, and the Industrial Technology Research Institute, Taiwan (R.O.C.) under grants G1-97005.

6. **References**

