An Adaptive Energy Management Scheme for Real-time Landslide Detection

Conference Paper · November 2013

DOI: 10.1145/2517351.2517381

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Poster Abstract: An Adaptive Energy Management Scheme for Real-time Landslide Detection

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ABSTRACT
Sensor nodes in wireless sensor network are powered by batteries and thus the utilization of effective energy management techniques becomes one of the most important challenges in realistic design of WSN. This paper deals with an optimal energy management scheme in Landslide detection system deployed in Kerala. Based on the meteorological, hydrological and soil parameters, sensors will be dynamically prioritized, scheduled and selects appropriate sensors for event handling. The results of this research work shows that the life time of the network has been improved due to the implementation of this adaptive energy management scheme.

Categories and Subject Descriptors
C.3.3 **Computer systems organization~Real-time system**

General Terms
Design, Documentation, Experimentation, Measurement, Performance, Reliability, Security, Theory

Keywords
Wireless Sensor Network, Energy optimization, Distributed algorithms

1. INTRODUCTION
Landslides are one of the major catastrophic disasters happening around the world. Wireless sensor networking technology [1] is one of the promising techniques to early detect these natural hazards and to reduce the impacts. Sensor nodes in WSN are powered by batteries with a limited lifetime and thus utilization of effective energy management techniques becomes one of the most important challenges in realistic design of WSN. This paper is an enhancement of the actual field deployment of a wireless sensor network based landslide detection system [2] deployed in India. A heterogeneous network, composed of wireless sensor nodes, Wi-Fi, and satellite terminals, is used to enable data collection and analysis and to provide landslide warnings and risk assessments to the inhabitants of the deployed region. This system improves its power utilization by using prioritization and dynamic selection of homogeneous and heterogeneous sensors based on the hydrological and soil properties.

2. WIRELESS SENSOR NETWORK FOR LANDSLIDE DETCTION
We have implemented a wireless sensor network for real-time landslide detection in one of the landslide prone area in Munnar, Kerala. This network consists of intelligent wireless probe (IWP) attached to sensors such as rainfall, moisture, pore pressure, and movement. This field deployment effort culminated in a fully functional network of more than 80 sensors that could be remotely triggered and monitored via satellite network (VSAT) from our campus.

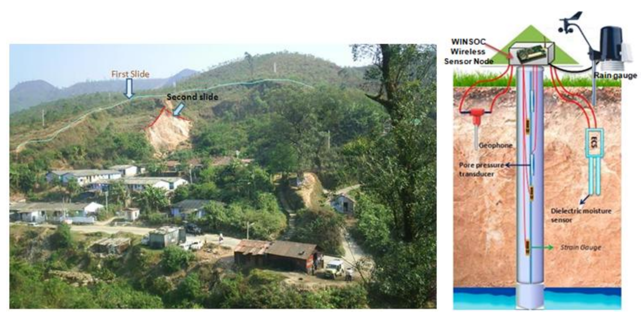

Figure 1: (a) Deployment site in Munnar, Kerala, India, and (b) Intelligent wireless Probe (IWP) with quad sensors

3. ARCHITECTURE OF IWP
The sensors used in IWP are rain gauge, dielectric moisture sensors, pore pressure piezometers, strain gauge, tiltmeters and geophones. In the current system all the sensors are always switched on and not optimally utilizing the battery power but IWP switch on only necessary sensors based on environmental conditions. Moisture content in the soil is monitored using the dielectric moisture sensor and huge increase in moisture content is considered to be a primary indication for landslide initiation. Pore pressure piezometers are used to capture the pore pressure variations, as the rainfall rate varies. To detect the movement in the ground types of sensors used are strain gauge, tilt meter and geophone. To reduce battery utilization, the system uses the state transition diagram. Initial state Sr is the least energy consuming state in which only rain gauge is active and hence the total energy in this state includes only sensing, processing and transmission of rain gauge sensor. If rain gauge sensor threshold exceeds, IWP switches to state Srm in which rain gauge and moisture sensors are active. Based on the environmental conditions, the system switches to different states of the state diagram as shown figure 2. Battery utilization in each state is described using following equations

$$E_{Sr} = E_{rsense} + E_{rtran} + E_{process} \quad (1)$$

$$E_{Srm} = E_{Sr} + E_{msense} + E_{mtrans} \quad (2)$$

$$E_{Srmp} = E_{Srm} + E_{psense} + E_{ptrans} \quad (3)$$

$$E_{Srmpt} = E_{Srm} + E_{tsense} + E_{ttrans} \quad (4)$$

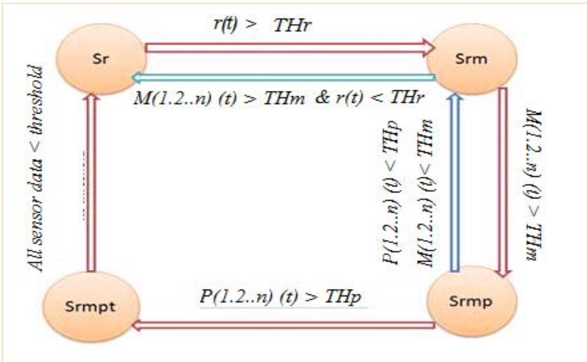

Figure 2. State transition diagram

In order to address the problem of energy management, the sensors in the wireless probe is assigned with two types of dynamic priorities, homogeneous priority and heterogeneous priority. In homogeneous prioritization, static priorities are assigned to all the sensors in the wireless probe and these priorities are updated based on the environmental condition. The prioritization algorithm computes the priorities of each sensor and order it based on soil properties. Heterogeneous priority is the priority of sensor with respect to other sensor which senses different parameter. Initially rain gauge is having highest priority. When a particular event occurs, priority of sensor at lower level will be decreased and the next higher level sensor will be given incremented priority.

4. RESULTS

We calculated the power utilization in the proposed system and compared with the current deployment. In the current system all the sensors are always rate same as Srmpt state. Figure 3 shows the comparison of required sensing energy for each transition state of the IWP. Figure 4 shows the difference in sensing energy for different seasons using the weather data of the year 2009. Data analysis shows that the percentage of energy savings in Summer is 78 % and a total of 56% of energy savings in whole year using IWP compared to the current system.

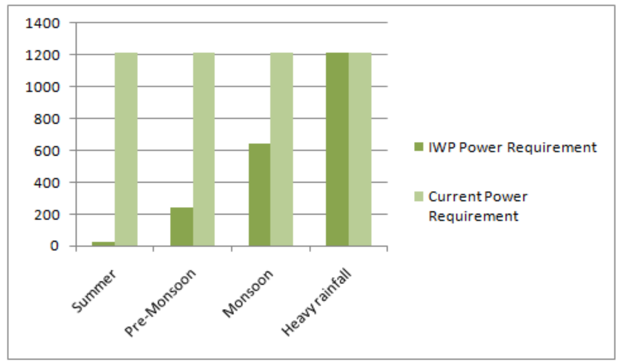

Figure 3. Power consumption in different seasons.

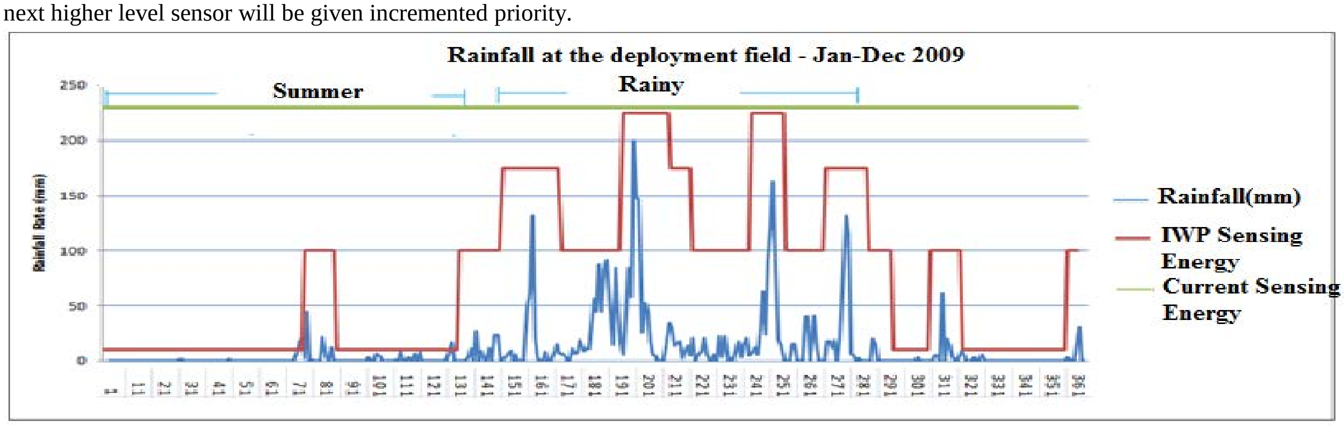

Figure 4. Comparison of sensing energy based on rainfall rate

5. CONCLUSIONS

This research explores the design and development of an intelligent wireless probe (IWP) for landslide detection. This method exploits hierarchical sensing and prioritized scheduling techniques for improving the life time of the network. Based on dynamic environmental conditions, homogeneous and heterogeneous priority assignments of different sensors in IWP help to switch off unnecessary sensors in the wireless probe. The experimental results show that the proposed adaptive energy management scheme provides excellent performance in terms of energy efficiency.

6. REFERENCES

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