Poster: Pilot Deployment of Early Warning System for Landslides in Eastern Himalayas

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ABSTRACT

Using wireless networks to connect and communicate between geological sensors is a more scalable and suitable way for designing landslide monitoring and warning system for larger areas spanning many acres. Added to this, if the system has the capability to function in solar power, then it becomes autonomous system with self-organizing and self-healing networks. But high terrain, steep slopes, dense vegetation and lack of light during monsoon season to generate solar power pose serious challenges to develop such an autonomous system with good wireless coverage. This paper is about efforts to design, develop and deploy one such landslide warning system in eastern Himalayas. Pilot deployment is already in place and full deployment is under progress.

Keywords
Wireless Networks; Remote Monitoring; Long range TDMA wifi; Lora; Landslides; Sensors.

1. INTRODUCTION

The Landslide prone zone in Chandmari (India) in Himalayas is spread across more than 40 acres .There were also some landslide at this palace during early 2004.A total of nearly 20 locations are strategically chosen here for sensor deployment based on the soil test results, current slope movement and local disaster departments advice. Each of these sensor locations has a Deep earth probe (DEP) deployed. A DEP is straight long narrow probe ranging from 3m to 20m consists of many heterogeneous type of sensors like pressure, movement, tiltmeter, vibration etc. They are deployed by drilling a bore hole (3m to 20 m) that is equal to probe length and buried underneath the ground. The electronics and wireless interfaces are connected to top of the DEP that is above the surface of the ground. They help in acquiring and processing the signals from the sensors and also communicate them to nearby nodes using wireless connections. Generating enough power to excite the sensors, signal conditioning circuits and the wireless interfaces round the clock is very challenging due to dense vegetation and lack of sunlight. Currently our power team is looking into different energy harvesting options available to resolve it.

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Fig 1. Deployment area of Chandmari, India in Google Maps

The pilot deployment consists of 4 DEP locations. Two at the crown part of the hill, one at the middle and one at the toe part of hill. Fig 1.shows the google aerial image of Chandmari, Sikkim, India and the encircled portion is the landside prone zone, where the full deployment is planned.

2. SYSTEM DESCRIPTION

The Proposed System architecture is shown in Fig 2.It consists of Field Management Center (FMC) for controlling all local operations to the field and Data management center (DMC) for remote command and control center with GUI detailed data analysis by geological experts. The sensor nodes in the field has multiple wireless network connections like peer-to-peer 802.15.4 communication, 802.11n Wifi network, Long Range TDMA WiFi for Backhaul, Wasp mote Lora PAN modules and 3G communications. Different wireless networks are employed based on varying bandwidth required by the nodes for real time data transfer of different sensors (higher sampling rate sensors like geophone needs more bandwidth than lower sampling rate sensors like moisture sensor), penetration levels at different sensor locations and limitations in generating solar power at these locations. More than one wireless connection in the nodes also helps to have redundancy for increased reliability during rough weather conditions.

The FMC houses Cisco Layer 3 routers/switches to form the secure Virtual Private Network tunnel between FMC and DMC. The WiFi/Ethernet network in the FMC helps to connect to Weather station and Sensor Node gateway. The Sensor Node

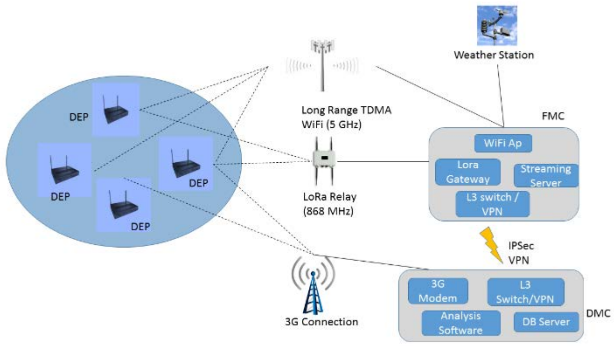

Fig 2.System Architecture

gateways are the cluster heads that helps to connect using Long range Wifi and Lora Relays to streaming server in FMC.

3. DEPLOYMENT

The Campbell weather station is configured and deployed in the field to get the real time environmental data of the site like rain, barometric pressure, sunlight, humidity, wind speed/direction and temperature etc. These parameters are vital to know the extent of emergency situations, like, heavy rains are the most that triggers the landslides. Along with this, pore pressure, tilt meter and vibration data are considered for landslide analysis.. Fig 3 and Fig 5 shows the real-time rain data and relative humidity received from field and plotted against samples numbers.

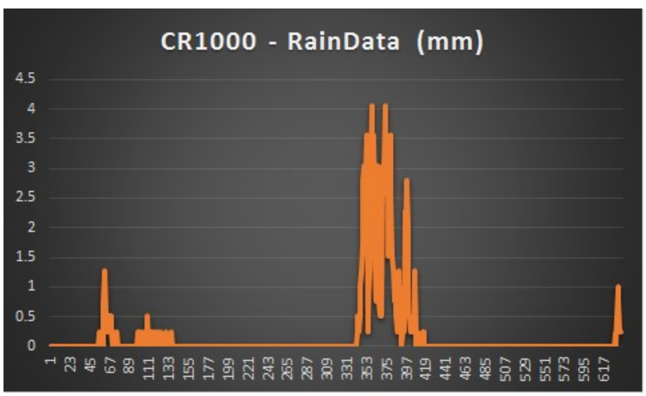

Fig 3.Rain Data from CR1000 Campbell weather station

Fig 4. DEP 3 connected with Sensors and Electronics.

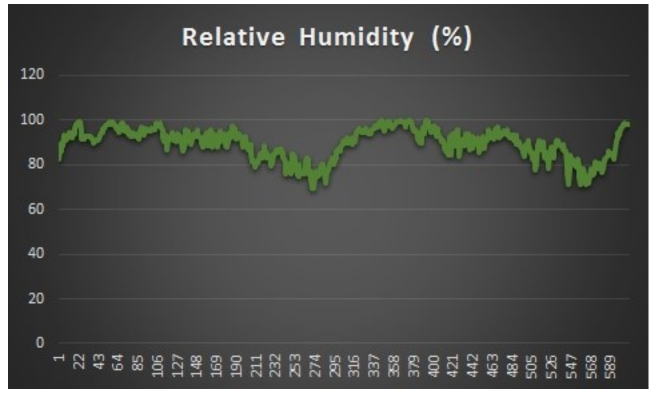

Fig 5. Humidity data from Deployment Site

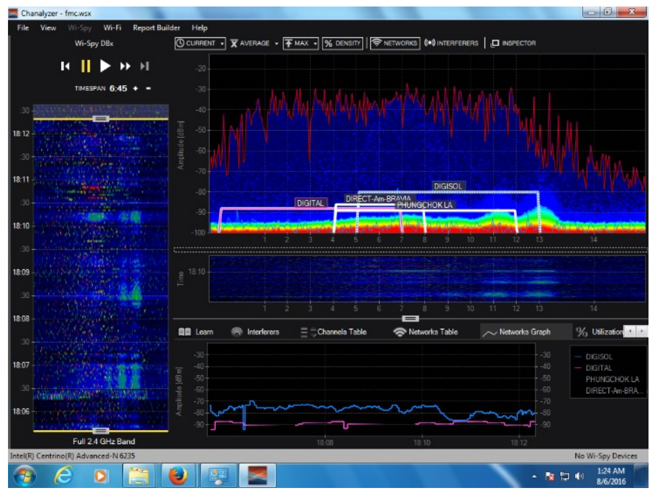

Fig 6. Density graph and Waterfall spectrum (2.4Ghz) near FMC

The weather station also houses a data logger that takes backup of the sensor data during fluctuation or unavailability of the network. The surrounding is very crowded in 2.4 GHz band with more Wifi, Bluetooth and cordless phone activity. Fig 6 shows the density graph and waterfall spectrum of traffic activity in 2.4 GHz band of the deployment site. The maximum signal strength of other networks reaches up to -30 dbm, causing more interference to landslide network. We plan to use redundant links using other type of networks, as a fail over option. 3G coverage is available in DEP1, 2, and 3, but in DEP4, due to high density of vegetation, there is only little coverage available. For the pilot deployment, 3G connection is used for streaming the data. So, each of the sensor node is equipped with 3G modem, to transmit the data to the DMC. Before transmitting the data in 3G, local backup of the data is also stored in the SD card of the sensor node before transmission. Fig 4 shows the DEP3 deployed with Sensors buried underground, signal conditioning electronics and Wireless interfaces inside the enclosures with solar panel mounted on the top.

4. CONCLUSION

In this paper we have seen deployment of sensor network based on GSM connection. But, it is found that sometimes GSM connection is unstable and fluctuating. Now we are looking to add redundant network using Long range TDMA Wi-Fi, Lora, 802.15.4 along with DSL connection to optimally use these networks based on power consumption and also on self-organizing capabilities between the nodes for efficient delivery of data to DMC.