Snow Avalanche Admonisher through Wireless Sensor Network

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ABSTRACT

The temperature reaches around -40°C to -60°C in hilly and mountainous areas during winters which may lead to many probable natural hazards. Defence personnel as well as civilians are unaware of these hazards. Amongst all the natural hazards, Snow Avalanche is one of the major hazards which has the probability of occurrence in the above listed temperature range. The aim of this paper is to bring in focus a proper system to alert the people about this hazard.

Keywords: Wireless sensor network (WSN), Avalanche, nodes, Parameter

1. INTRODUCTION

To alert the defence personnel and local people from avalanche, we have designed a system that operates through wireless sensor network. It comprises of network nodes with wireless sensor that senses the temperature and other requisite parameters (that may be temperature, pressure or other physical quantities of importance in the context) on a continual basis and transmits the data to the/their base station for further processing.

Snow avalanche occurs whenever newly generated snow accumulates on a heavy snow layer and does not properly adhere to the existing layer thereby resulting in avalanche breakdown. It then leads to various sort of vibration caused due to skating, firing etc.

WSN is a collection of various sensors that monitors the environmental and physical conditions like weather condition, snow steepness, slope orientation, vibration, humidity and pollutant ion.

2. SYSTEM OVERVIEW

Nodes are distributed in the hierarchical manner or in cluster form with WSN and sense the parameters continually and route the information to other nodes at the final destination, the base station. For forwarding the data from a source node i.e. WSN to destination node i.e. base station, we use unicast or multicast algorithm between the nodes. Base station observes the parameters periodically and whenever a change is observed, it broadcasts the information through radio waves. The receiver receives the data periodically and upon receiving any plausible information about any upcoming hazards, it takes necessary steps to alert the people residing in the endangered locality.

3. MAJOR MODULES OF THE SYSTEM

A WSN consists of spatially distributed nodes to monitor physical or environmental parameters such as temperature, pressure, humidity, sound intensity, variation, motion and cooperatively pass the data through a network to the base station.

WSN is built up of "nodes" where each node is connected to sensor. The number of these nodes varies from few hundreds to thousands

A. Node:

Each node in a sensor network is typically equipped with a radio transceiver (that has either an internal antenna or is connected to an external antenna), a microcontroller, a circuit to interface with sensors and a power source like battery. All the sensors sense the data, convert analog signal into digital signal and send the signal towards a microcontroller. Microcontroller has a memory with it along with a transceiver.

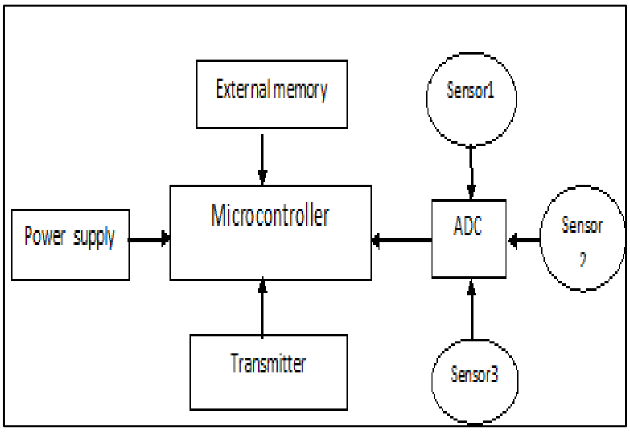

Figure 1: Architecture of each node

The nodes should qualify below mentioned important features for successful application in the snow bound region:

- The nodes should be automated for maintenance free functioning and robust to withstand harsh environment.
- The nodes should also have low power for long-term operation.
- The working temperature range for the node has to be in the range of -40 to +30°C.

B. Base Station:

The Base Station receives data from each node at a predefined radio frequency range. The data received by the base station is monitored and on the basis of monitored data, it sends information to the radio receivers (cops or public). A database can be created where all the received data can be stored in commercial database or spread sheet for further processing and analysis. It can also be shared to internet to access from any location.

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Figure 2: Base Station

C. Communication:

The nature of the environment for the communication must meet the requirements of high power unidirectional transmission for long-range (up to 300m) from node to base transmission with low data-rate of few kbps, error-detection and correction. The energy used for communication of WSN is reduced by multiplehops instead of single high power transmission. Nodes placement is on line of sight with based station. Communication of nodes with each other increases the performance of the network. The sampling and quantization level rate can be modified as per the required accuracy/baud rate from the base station end. Node, being a solid state, will consume less power and further to enhance power efficiency. Wave and serve principle is used in the design

D. Networking:

WSNs have self compensating and self configuration capabilities. They can be setup in the snow bound area for snow-met data collection at various points with higher scalability. Each node monitors the radio traffic in its neighbourhood & keeps track of possible alternate radio paths, whenever required. Each node provides definite delivery to its nearest base node. The sensor nodes and gateways can be configured for auto routing and self-compensating network with the help of which the nodes can deploy themselves rapidly into a multi-hop wireless sensor mesh network topology. This also helps in extending the range of coverage.

4. ARCHITECTURAL NETWORK

The architectural diagrams for the network is shown below:

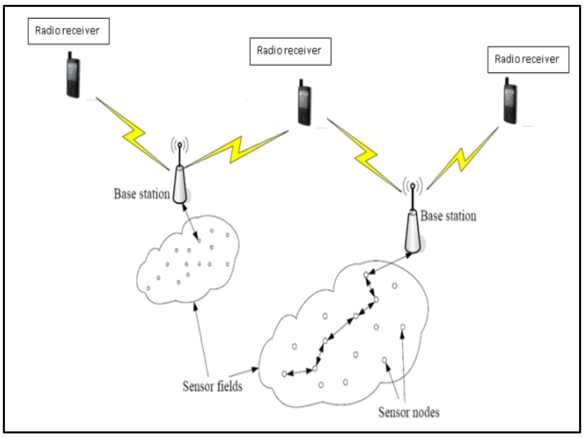

Figure 3: Architecture Network

A. Sensor:

The physical level analog device observes physical and environmental changes and sends out the data to the microcontroller via ADC. The sensors are going to use use to sense snow avalanche break-down are temperature sensor, humidity sensor, vibration sensor, pressure sensor to measure snow surface parameters. The sensors used must be of compact size and should have low power consumption capabilities.

B. ADC:

ADC (analog to digital converter) converts the analog signal received from sensors to digital signal for the purpose of processing into the microcontroller. ADC can be an in-built ADC or external ADC chip, depending upon the microcontroller being used.

C. Microcontroller:

Microcontroller collects the digital data from analog to digital (ADC), processes it and further sends it to the base station via transmitter. It also prioritizes the important data on the basis of standard range of parameters of environment by which congestion in the network is controlled. It processes data from the sensor based upon its priority and when the data shows any variation over the preset range, it is embedded in the form of algorithm in the microcontroller

D. Memory:

Memory is used to store program code, to hold the data for routing process and backup purpose and to transfer the data to some other location .

E. Power source:

Various type of power source that can be used in the project includes solar power and rechargeable batteries. Best solution may be to use both solar cell and Li-ion Battery are best suited, however other batteries such as Ni-Cd, and lead acid may also be used depending upon the mode of recharging and desired weight of the unit. The battery is charged whenever the solar cell is active.

F. Transceiver:

Transceiver transmits the data sent by the microcontroller particularly in radio frequency. The operating mode of transmitter is controlled by microcontroller for data transmitted data, received data and idle case. The system is based upon wake and serves principle in order to further minimize the power consumption.

5. SPECIFICATION OF MAJOR COMPONENTS

A. Temperature sensor:

RTD is employed for temperature sensing. It is best suited for our purpose because of its solid state construction, linear characteristics and temperature range. Alternatively a thermistor may also be used if its non linearity can be tolerated. Specification of RTD 600 is provided for reference:

Dimension	3 in (7.6 mm) length 1/4 in (6 mm) diameter
Accuracy	±0.3°F (0.2°C)
Range	–100°F to 300°F (–73°C to 149°C)
Resistance	100 ohms +/– .25 ohm at 0°C X=0.00385 ohms/ohm/°C

Figure 4: Temperature sensor

B. Pressure sensor[7]:

Since we are measuring the relative atmospheric pressure so barometric pressure type sensor is best suited for pressure sensing deployment. The specification of the same is shown:

Proof Pressure:	1.0 PSI (either port)
Burst Pressure:	1.5 PSI (either port))
Supply Voltage:	5.0 ± 0.25 Vdc
Supply Current:	4mA Max.
Temperature Effects (10° to 40°C):	±2% of span Max.
Output Impedance:	100 Ω Max.
Service Life:	10,000,000 cycles Min.
Vibration:	1 g from 20 Hz to 1200 Hz
Operating Temperature:	-40°C to 60°C
Humidity:	95% RH, non-condensing
Weight:	20 grams Max.

Figure 5: Pressure sensor

C. Humidity sensor:

Humidity sensor is used to measure only the relative humidity for conveying the change of the atmospheric humidity. Thus relative humidity measuring sensor HS 1100/1101 is deployed with the following specification:

RATINGS	VALUES
Operating Temperature	-40 to 100°C
Storage Temperature	-40 to 125°C
Supply Voltage	10 Vac
Humidity Operating Range	0 to 100% RH
Soldering @ T = 260°C	10 s

Figure 6: Humidity sensor

D. Vibration Sensor

For the purpose of measuring vibration and reducing power consumption, paves the way towards MEMS vibration sensor. A typical vibration sensor VS 9200 D is shown below:

Full scale range	± 200g	
Packaging		
Bandwidth, (± 5 %) [3]	0 to > 1000	Hz
Noise spectral density in band	25	µV/√Hz typ.
[0 ; 400 Hz]	27	Max.
Bias calibration	< 1000	mg
One year bias stability [1]	150 (<500)	mg typ. (max.)
Switch on/off repeatability	< 15.0	mg max.
Bias temp. coefficient [2]	< 10.0	mg/°C typ.
	± 40	mg/°C max.
Resolution / Threshold (@ 1Hz)	< 11.0	mg max.
Non linearity [4]	< 1	% of FS max.
	< 2	g max.

Figure 7: Vibration sensor

D. Transreceiver:

In order to transmit the data through wireless and to take into account the possible distance between the base station and the module, long range RF module is deployed. The specification of one such transceiver is shown below of range 1Km. It is noteworthy to know that if required the range can be successfully increased through the use of further long range FSK module pin compatible with the below listed one:

Parameter	Min	Max	Units	Condition
Supply voltage	–0.3	3.5	V	All supply pins must have the same voltage
Voltage on any digital pin	–0.3	VDD+0.3, max 3.6	V	
Voltage on the pins RF_P, RF_N and DCOUPL	–0.3	2.0	V	
Input RF level		TBD	dBm	
Storage temperature range	–50	150	°C	
Solder reflow temperature		260	°C	T = 10 s
ESD		2	kV	All pads (excluding RF) have 2kV HBM ESD protection

Figure 8: Transreceiver

The function of each pin is also mentioned below:

Pin #	Pin name	Pin type for module	Description
1	VCC	Power	1.8~3.6V power supply
2	GND	Ground	
3	SI	Digital Input	Serial configuration interface, data input
4	SCLK	Digital Input	Serial configuration interface, clock input
5	SO	Digital Output	Serial configuration interface, clock input Optional general output pin when CSN is high
6	GDO2	Digital I/O	Digital output pin for general use >Test signals >FIFO status signals >Clear Channel indicator >Clock output, down-divided from Xosc >Serial output RX data
7	GDO0	Digital I/O	Digital output pin for general use: >Test signals >FIFO status signals >Clear Channel indicator >Clock output RX data >Serial output RX data >Serial input TX data Also used as analog test I/O for prototype/production testing
8	CSn	Digital Input	Serial configuration interface ,chip select

Figure 9: Each pin specefication

6. CONCLUSION

Sensing the data and transmit to base station via wireless sensor and provide the congestion free network because microcontroller transmit only those data to base station which are changed. In this manner only valuable and needed data is forwarded that avoids congestion in network.

By achieving this wsn we can alert the Defence personnel as well as civilians so that they can take necessary steps or precaution before avalanche happens.

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