To design an architectural model to deploy wireless sensor network for forest fire hazard management

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- Forest are part of the important and indispensable resources for human survival and social development .
- The prevention and monitoring of forest fires has become a global concern.
- Forest fires are among the most serious disasters to forest resources and human environment.
- In recent years, the frequency of forest fires has increased considerably due to climate change and human activities.

- The normal fire season in India is from the month of april to mid-June. The Himalayan forests, particularly, Garhwal Himalayas have been burning regularly during the last few summers, with colossal loss of vegetation cover of that region. [13]

- In Uttaranchal 8 hill districts mainly Chamoli, Pithoragarh, Almora, Nainital, Uttarkashi, Dehradun, Tehri, and Pouri, are highly vulnerable area of forest fire. [13]

- Every year one third of all forests are affected by the forest fire in Uttaranchal. In the recent years a very large part of the forest has been destroyed in Uttaranchal in the name of development. [13]

- Climate play a greater role in the outbreak of wild fire, which in turn with abnormalities leads to increase in the chances of wild fire incidences in Sikkim Increasing number of forest fires in Sikkim has led to ecosystem vulnerability resulting in immense threat to forest diversity.[13]

- Decreasing annual rainfall and dry spells during winters together with increasing mean minimum temperature leads to warmer climate and heavy pressure on the forest ecosystem.

- Furthermore, high intensity of forest fires in Sub- tropical forests leads to severe threat to biodiversity and renewable early 55% of the total forest cover in India is prone to fires every year.

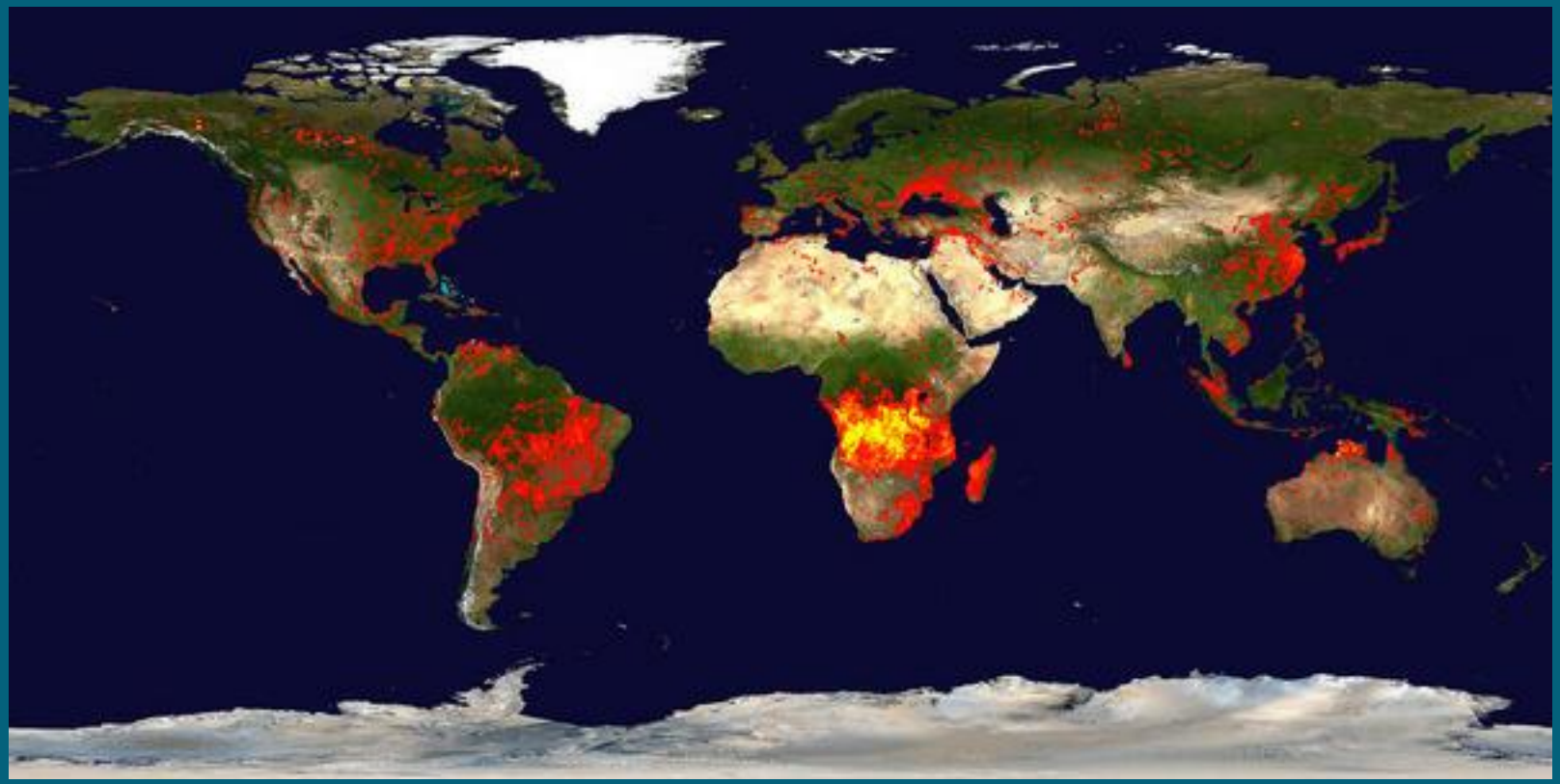
- An estimated annual economic loss of Rs.4400 million is reported on account of forest fires over the country.

- April to June is a period when the temperature is more than 40 degree Celsius As per State of Forest Report for Arunachal Pradesh, about 82% of total geographical area of 83,740 sq. kms which is about 62% of the total geographical area and includes 10185.40 sq. km. of Reserve & Protected Forests which is about 12% of the area while the Protected Area Network covers an area of 9527.99 sq. km being 12% of the area and balance 38% is Unclassified Forest.[14]

- Environmental parameters such as temperature and humidity in the forest region can be monitored in real-time. Forest fire occurs at a temperature of 40 to 45 degree Celsius

Global Fire Map

Global distribution of fire occurrences over a 10-day period by the beginning of the week



- Environmental parameter for example temperature and humidity in the forest region can be monitored in real time.
- From the information collected by the wireless sensor network system decision for fire prevention and fire fighting can be made more quickly.
- The WSN system can monitor real-time related parameters e.g. temperature, relative humidity and send the data immediately to the computer of the monitoring centre.
- The collected data will be analyzed and managed by the computer compared with the controlled variable and then system can make a quick assessment of a potential fire danger.
- The process of the network will be compared with the expected theoretical behavior

- Three factors compose the basis of a forest fire: the fire source, environmental elements and combustible material. A forest fire usually occurs as the result of their combined effects .

- The moisture content of the combustible material plays an important role in forest fires, which means the probability of forest fires depends on the moisture content.

- The moisture content has much to do with relative humidity in the atmosphere, air temperature, wind and similar factors.

- Forest fire occurs at a temperature of 40 to 45 degree clesius

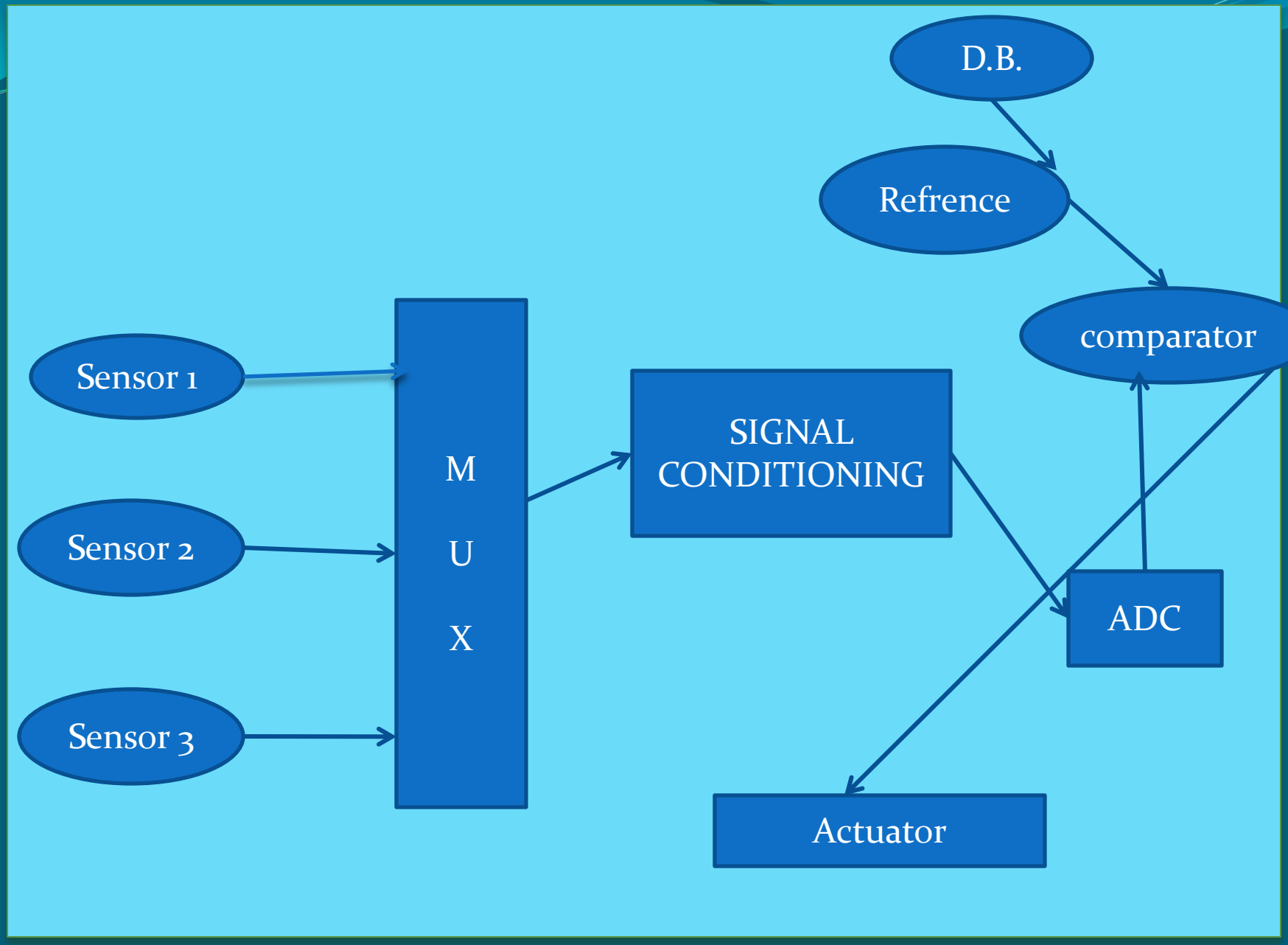
- Fire occurs when the value of temperature is higher then the humidity.

- When the weather is dry and hot, a fire can occur with high probability.

- The task of sensor is to sense the environment and to measure the appropriate parameters and send it to the base station.

- Sensor is a device that measures a physical quantity and converts it into a signal.
- Wireless sensor network are a network of small sensing devices that can collaborate with each other to process data and communicate over wireless channel. It consists of four main parts

1) A Rf (Radion frequency wave communication)
2) A Processor
3) Sensors
4) battery

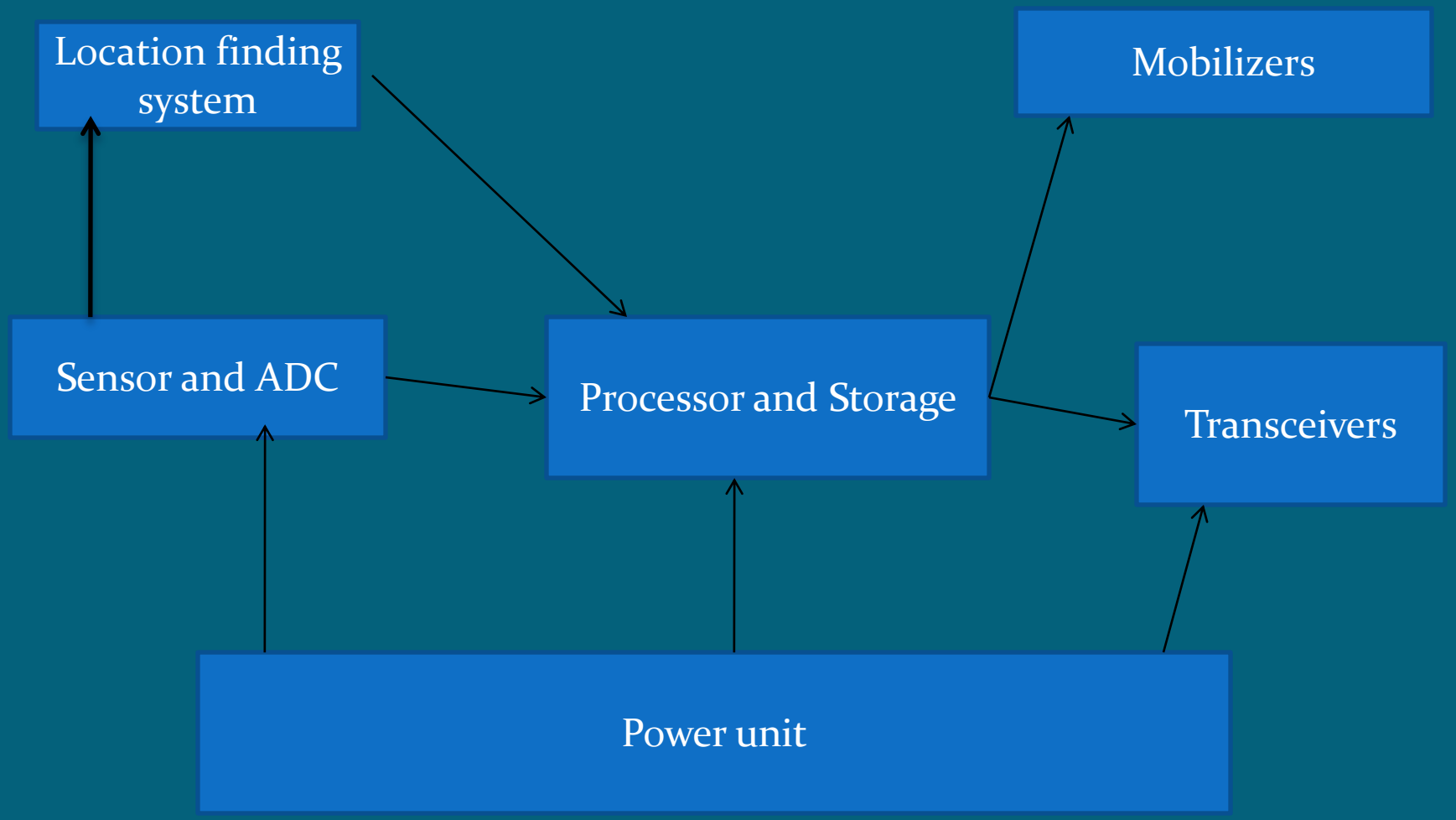

D.B.
Refrence
comparator
Sensor 1
Sensor 2
Sensor 3
M
U
X
SIGNAL
CONDITIONING
ADC
Actuator

- Wireless sensor network architecture
- Sensor deployment scheme
- Clustering communication protocol
- Energy consumption

Here sensor nodes are deployed with ranges upto 1 km.

Average distance between sensor neighboring node should be reduced to reduce the time expected for fire detection. Value of temperature and humidity are calculated by cluster head.(Max, Min & Avg). Data is propagated only when certain threshold is exceed.

Components of sensor node



Sensors sense and interpret data from the environment and react to various situations.
Sensor needed are:

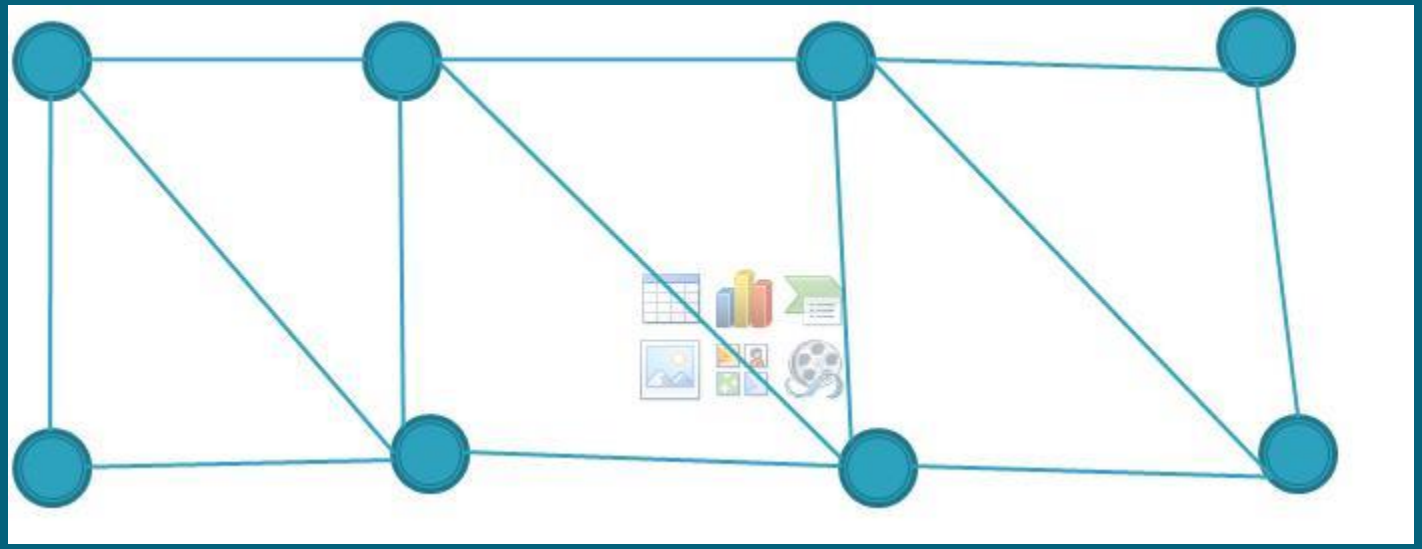
- Temperature sensor
- Humidity sensor
- Carbon dioxide sensor
- Wind speed sensor

factor that affects the performance of a fire detection WSN system is the deployment of sensor node

- Two general approaches can be considered to define the deployment pattern:
- (1) regular deployment,
- or (2) random deployment.
- In case of regular (homogeneous) deployment, nodes are deployed according to a regular pattern and we have nearly equal distance between neighboring nodes. Therefore, all

sensor nodes transmit their messages to similar distances. This leads to balanced transmit energy consumption throughout the network.

Geometry of sensors to be placed



- In random (non-homogeneous) deployment, nodes are deployed randomly (from a plane maybe) without following a regular pattern, hence the distance between two neighboring nodes is a random value, which may or may not be uniformly distributed.

- In this case, some sensor nodes may have quite distant neighbors and therefore may have to transmit to longer distances. Since the transmit energy consumption increases exponentially with the distance, those sensor nodes will consume much more energy due to transmissions and therefore will run out of energy earlier.

- Transmitting to longer distances to reach to some neighbors may also increase the interference on other nodes and may cause an increase in the collision probability.

Sensor deployment scheme:

The sensor node deployment scheme can affect the design and performance of all aspects of the system. In a deployment scheme, there are two major decisions to make:

(1) What should be the average distance between neighboring sensor nodes?

(2) What should be the deployment pattern or distribution (random or a regular pattern)?

(3) The average deployment distance between neighboring sensor nodes is an important parameter that affects the performance of a wireless sensor network deployed for fire detection.

(4) The time to detect a temperature increase at a node due to a fire is related with the distance of the node to the fire ignition location. Therefore, in order to reduce the expected fire detection time, the average distance between neighboring sensor nodes should be reduced

Network architecture and topology design

- Flat network topology : sensor nodes in placed in a totally distributed manner with equal responsibility.
- Hierarchical cluster topology: Some nodes are designed as cluster head with more responsibility to control other members.
- Cluster logical topology

Cluster network architecture

Protocols for intra cluster communication and inter cluster communication.

Risk Free time phase

Sleep mode in Round Robin fashion here sensing is less.

Average , Min and Max value of temperature and humidity are calculated

Algorithm and issues:

Directed diffusion algorithm

Sensor network query processing algorithm

Localization in sensor network

Multi object parameter

Security

- Structured node: Low maintenance and low cost
- Generic node: gather data from generic sensors and relating them to the base station

With higher processing capabilities

Terrestrial Wsn:

Adhoc: (unstructured

Preplanned(structured)

Internal sensor system diagnostic and debugging

1) Measure and Monitor
2) Connectivity
3) Data flow
4) Nodes localization

Network services:

- 1) localization
- 2) Synchronization
- 3) coverage
- 4) Compression and aggregation
- 5) Security
- 6) Energy and power consumption

Moores algorithm

distributed algorithm for location estimation without the use of GPS.

Algorithm has three phase

1) Cluster localization phase
2) Cluster optimization phase
3) Cluster transformation phase

Time synchronization is important for :

Routing

Power conservation

Life time

Cooperation

Scheduling

Network services compression and aggregation:

Data compression : compression of data

Data aggregation:

data is collected from sensors

Combined together to a base station

Its is used in cluster base technology

Simulation

- Discrete-Event Simulation- easily simulate lots of jobs running on different sensors. List of pending events , routing.
- Trace-Driven Simulation: used in real time system, cost low

- Simulation Tool

NS 2, Tossim, Emstar

They can not solve energy issue, power issue not used for long nodes

OMNET++, J-Sim, ATEML, Avrora

Support MAC help in energy consumption.

Operate on Tiny OS

RESULTS AND DISCUSSIONS

- In the beginning data for 5 yrs especially for humidity and temperature be considered and based on that data the entire area will be divided into three zones, green where there is no possibility of fire, Red- where there is every possibility of fire to estimated area, the intensity of a wireless sensor will be intensifier and based on the annual data for humidity and temperature, the area prone to fire will be narrowed down and where vey specific arrangement with regard to number of sensors or frequency to keep the sensors in active mode will be decided.

- The rest of the area will be yellow where sensors will be laid on the basis of data for humidity and temperature.
- Over a period of time, warehouse of data for humidity and ambient temperature prevailing in the state of Arunachal Pradesh will be developed.

Results and discussions contd..

- In the beginning all the data available will be place in the ware house, as per as possible in public domain and where such data are considered sensitive, such data could be placed in the ware house specially developed for this purpose, Arunachal Pradesh could also be divided into Green, Red depending upon climate zone in which the area is located.
- 1) Green State: This is the lowest risk level for a possible
- fire danger. In this initial level, the sensor node sensing
- periods are longer compared to other levels.
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- 2) Yellow State: This is the medium risk level. This state
- may have transitions to either Green or Red state.
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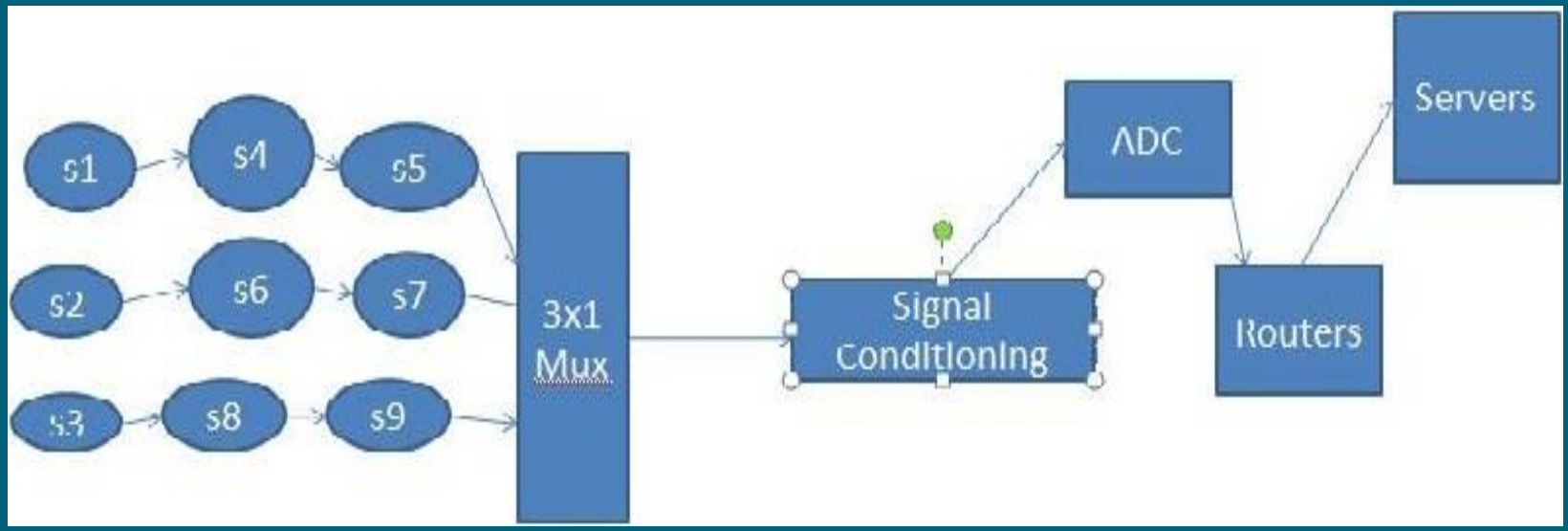
- 3) Red State: This is the highest risk level. The algorithm can initiate a fire alarm only on this state.

Conclusion and Future Perspective

- Firstly main computer server inquires about the information through messages from sensors which are deployed in a forest area. The sensors respond to it by transmitting the data to the main server this information consists of values of temperature and humidity of forest area.

- This data is collected and transmitted to other clusters head. Through the network coordinator the fused data is sent to router and then it is sent to main computer server. This information collected by main computer server is very much helpful for forest department. For future use we can have two to three more main computer servers.

System Architecture of Wireless Sensor Network System



Reference

- K. M. Sivalingam, M.B. and P. Agrawal, "Low Power Link and Access Protocols for Wireless MultimediaNetworks", *Proceedings IEEE Vehicular Technology Conference VTC'97, May 1997.*
- http://en.wikipedia.org
- W. Mangione-Smith and P.S. Ghang, "A Low Power Medium Access Control Protocol for Portable Multimedia Systems", *In Proceeding 3rd Intl. Workshop on Mobile Multimedia Communications, Princeton, NJ, Sept. 25-27, 1996.*
- A. A. Ahmed, H. Shi, and Y. Shang, "Sharp: A new approach to relative localization in wirelesssensor networks," in *Proceedings of IEEE ICDCS*, 2005.
- Arshak, K. Jafer, E. " A Wireless Sensor Network System for Pressure and Temperature Signals Monitoring"*IEEE Conference Proceeding, 4-7 June 2007 Page(s):1496 – 1501.*
- EimanElnahrawy, Xiaoyan Li and Richard P. Martin, " The Limits of Localization Using Signal Strength: A Comparative Study, *in* Proceedings of IEEE SECON, pp. 406-414, Santa Clara, California, USA, October 2004.
- Stipanicev, D., Bodrozic, Lj.,Stula, M.: Environmental Intelligence Based on Advanced Sensor Networks. In: *Proceedings of 14th International Workshop on 2007 IWSSIP&ECSIPMCS. Maribor, Slovenia (2007.)*
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- Chong, C., Kumar, S.: Sensor Networks: Evolution, Opportunities and Challenges. In: *Proceedings of the IEEE, Vol.91, No.8, pp. 1247--1256. IEEE Press, New York (2003.).*
- R. Bekkerman, R. El-Yaniv, Y. Winter, and N. Tishby. On feature distributional clustering for text categorization.*InACM SIGIR, pages 146–153, 2001.*
- YunusAmreAslan, Ibrahim korpeoglu and OzgurUlusoy. AFramework for use of wireless sensor networks in forst fire detection and monitoring.*Computers, Environment and Urban Systems, Vol. 36, No 6, pp. 614-625, November 2012.*
- Junguo ZHANG, Wenbin LI, Ning HAN and Jiangming KAN. Forest fire detection system based on ZigBee wireless sensor network. Higher Education Press and Springer-Verlag 2008, Front.For.China 2008,3(3): 369-374.
- ChalermekIntanagonwiwat, Ramesh Govindan, and Deborah Estrin. Directed diffusion: A scalable and robust communication paradigm for sensor networks. *Technical Report 00-732, University of Southern California,March 2000.*
- http://www.fsi.org.in/
- http://arunachalforests.gov.in