Wireless Sensor Networks for Fire Detection and Control

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Abstract- Due to current technological progress, the manufacturing of tiny and low price sensors became technically and economically feasible. Sensors can measure physical surroundings related to the environment and convert them into an electric signal. A huge quantity of these disposable sensors is networked to detect and monitor fire. This paper provides an analysis of utilisation of wireless sensor networks for fire detection and control.

Keywords- *Fire Detection, Wireless Sensor Networks, Fire control, Disaster Control*

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I. Introduction

Wireless Sensor Network (WSN) consists of spatially distributed autonomous sensors to cooperatively monitor physical or environment conditions, such as temperature, sound, Vibration, pressure, motion or pollutants[1][2]. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance and are now used in many industrial and civilian applications areas, industrial process monitoring and control, machine health monitoring environment, habitat monitoring, healthcare applications, home automation and traffic control [3][4][5].

In addition to one or more sensors, each node in a sensor network is typically equipped with a radio transceiver or other wireless communications device, a small microcontroller, an energy source and usually a battery. A sensor network normally constitutes a wireless ad-hoc network that each sensor supports a multi-hop routing algorithm where nodes function as forwarders and relaying data packets to a base station[1].

1.1 Components of Sensor

Each sensor node comprises sensing, processing, sending, receiving, mobilizer, position finding system and power units [6]. The
complexity of wireless sensor networks, which generally consist of a data acquisition network and a data distribution network, monitored and controlled by a management centre [6]. The components difficulty let alone the design of a consistent, reliable, robust overall system. The study of wireless sensor networks is challenging in that it requires an enormous breadth from an enormous variety of disciplines.

1.2 Components of WSN

WSN nodes combine with routers and a gateway to create a typical WSN system [7]. The base stations are one or more components of the WSN with much more computational, energy and communication resources, act as a gateway between sensor nodes and the end user. The nodes communicate wirelessly to a central gateway, which provides a connection to the wired world where we can collect, process, analyze, and present your measurement data. To extend distance and reliability in a wireless sensor network, we can use routers to gain an additional communication link between end nodes and the gateway.

Other special components in routing based networks are routers, designed to compute, calculate and distribute the routing tables. Many techniques are used to connect to the outside world including mobile phone networks, satellite phones, radio modems, Wi-Fi links etc.

1.3 Protocols

The 802.11 protocol, the first standard for wireless local area networks (WLANs), was introduced in 1997. It was upgraded to 802.11b with an increased data rate and CSMA/CA mechanisms for medium access control (MAC). Although designed for wireless LANs that usually consist of laptops and PDAs, the 802.11 protocols are also assumed by many early efforts on WSNs. However, the high power consumption and excessively high data rate of 802.11 protocols are not suitable for WSNs. This fact has motivated several research efforts to design energy efficient MAC protocols [8].

Recently, the ***802.15.4***-based ZigBee protocol was released, which was specially designed for short range and low data rate wireless personal area networks (WPAN). Its applicability to WSNs was soon supported by several commercial sensor node products, including Micaz, Telos and Ember products .Above the physical and MAC layers, routing techniques in wireless networks are another important research direction for WSNs. Some early routing protocols in WSNs are actually existing routing protocols for wireless ad hoc networks or wireless mobile networks. These protocols, including DSR and AODV, are hardly applicable to WSNs due to their high power consumption. They are also designed to support general routing requests in wireless networks, without considering specific communication patterns in WSNs. Nevertheless, the customization of these protocols for WSNs and the development of new routing techniques have become hot research topics [8].

1.4 Operating System used in Wireless Sensor Networks

Operating systems for wireless sensor network nodes are typically less complex than general-purpose operating systems for example sensor network applications are usually not interactive in the same way as applications for PCs. The operating system does not need to include support for user interfaces.

Furthermore, the resource constraints in terms of memory and memory mapping hardware support make mechanisms such as virtual memory either unnecessary or impossible to implement. Wireless sensor network hardware is not different from traditional embedded systems and it is therefore possible to use embedded operating systems such as eCos or uC/OS for sensor networks. However, Operating systems are often designed with real-time properties [9].

TinyOS is perhaps the first operating system specifically designed for wireless sensor networks [10]. Unlike most other operating systems, TinyOS is based on an event-driven programming model instead of multithreading. TinyOS programs are composed into event handlers and tasks with run to completion-semantics. When an external event occurs, such as an incoming data packet or a sensor reading, TinyOS calls the appropriate event handler to handle the event [9]. Event handlers can post tasks that are scheduled by the TinyOS kernel sometime later [10]. Both the TinyOS system and programs written for TinyOS are written in a special programming language called nesC which is an extension to the C programming language [9]. There are also operating systems that allow programming in C. Examples of such operating systems include Contiki, MANTIS, B Tnutand Nano-RK [11, 12]. Contiki is designed to support loading modules over the network [9].The Contiki kernel is event-driven,like TinyOS, but the system supports multithreading on a per-application basis [13] . Furthermore, Contiki includes proto threads that provide a thread –like programming abstraction but with a very small memory overhead [13, 14].

Unlike the event-driven Contiki kernel, MANTIS and Nano-RK kernels are based on preemptive multithreading [15].With preemptive multithreading applications do not need to explicitly yield the micro process to other processes. Instead, the kernel divides the time between the active processes and decides which process that currently can be run which makes application programming easier. Nano-RK is a real-time resource kernel that allows fine grained control of the way tasks get access to CPU time, networking and sensors.

Like TinyOS and Contiki, SOS is an event-driven operating system [12]. The prime feature of SOS is its support for loadable modules. A complete system is built from smaller modules, possibly at run-time. To support the inherent dynamism in its module interface, SOS also focuses on support for dynamic memory management. BTnut is based on cooperative multi-threading and plain C code [12]. LiteOS is a newly developed OS for wireless sensor networks, which provides UNIX like abstraction and support for C programming language[11]. ERIKA Enterprise is one of the newcomers as operating systems for sensor networks. Being an open-source real-time kernel, ERIKA Enterprise Provides an operating system API similar to the OSEK/VDX API used in automotive, together with the wireless software stack providing a802.15.4 with Guaranteed Time Slot(GTS) support, which is very important when there is need for real-time traffic guarantees on wireless sensor networks[15].

Event Handlers: Each component handles certain events. When an external event occurs, such as an incoming data packet or a sensor reading, TinyOS signals the appropriate event handler to handle the event. That event will bring the required execution context with it. When the event processing is completed, it is returned back to the system. Event handlers can post tasks that are scheduled by the TinyOS kernel some time later.

Tasks: A limiting factor of an event based program is that long-running calculations can disrupt the execution of other time critical subsystems. If an event were to never complete, all other system functions would halt. To allow for long running computation, TinyOS provides an execution mechanism called **tasks**. A task is an execution context that runs to completion in the background without interfering with other system events. Tasks can be scheduled at any time but will not execute until current pending events are completed. Tasks allow long running computation to occur in the background while system event processing continues. Currently task scheduling is performed using a simple FIFO scheduling queue. While it is possible to efficiently implement priority scheduling for tasks, it is unusual to have multiple outstanding tasks.

II. Introduction to Fire

Fire is fast and self-sustaining oxidation procedure escorted by heat and glow in altering intensities. Fire is based on three ingredients: fuel, temperature and oxidizer. **F**ire has been a foundation of ease and disaster for the human being. Fire calamity can take place in air, on ground, and in mines [16]. Flammable chemicals, Processes involving open flame, Heat producing devices, Use and disposal of chemicals, electrical equipment short circuiting and Causal Factors are major causes of fire.

2.1 Types of fire

Fire can be broadly divided into two types depending on the reason of fire outbreak:

- **Natural**: Fires caused by earthquake, volcanic eruption, lightning is considered as natural fire [17].
- **Manmade:** Fire outbreak due to human and machine errors is called manmade fires like industrial and chemical fire tragedies, fires at social get-together and accidental fire.

III. Work done to detect and control fire using WSN

WSNs use equipments that are lighter, smaller and have less power consumption. This application of WSN has many challenges that include data collection, event detection, high data rates and sparse deployment of nodes. This section provides review of paper related to fire detection and control using WSNs.

A. Mainwaring et al. [18] described features of robustness, self-organizing, low-cost and fault tolerance make sensor networks appropriate for military use. Distributed sensing has the advantages of being able to provide redundant and hence highly reliable information on threats as well as the ability to localize threats by both coherent and incoherent processing among the distributed sensor nodes. It includes variety military applications, forest fire detection and animal monitoring.

M.Bahrepour, N. Meratnia and P.J.M. Havinga [19] explained automatic fire detection is important for early detection and promptly extinguishing fire. They investigate best combinations of sensors and appropriate techniques for early fire detection. Fire detection has either been considered as an application of a certain field or the main concern for which techniques have been specifically designed.

M. Hefeeda and M. Bagheri [20] described early detection of forest fires is the primary way of minimizing their damages. They present the design of a wireless sensor network for early detection of forest fires. They started with the key aspects in modelling forest fires according to the Fire Weather Index (FWI) System which is one of the most comprehensive forest fire danger rating systems in North America. Then, they model the forest fire detection problem as a node *k*-coverage problem (k>1) in wireless sensor networks. They propose approximation algorithms for the node *k*-coverage problem which is shown to be NP-hard. They present a constant-factor centralized algorithm, and a fully distributed version which does not require sensors know their locations. Our simulation study demonstrates that their algorithms: activate near-optimal number of sensors, converge much faster than other algorithms, significantly prolong the network lifetime, and can achieve unequal monitoring of different zones in the forest.

C. Intanagonwiwat, R. Govindan and D. Estrin [21] explained sensor networks have different requirements than other wireless networks. The need for robustness and scalability leads to the design of localized algorithms, where sensors only interact with other sensors in restricted vicinity and have at best an indirect global view. They proceed to describe a two-level cluster formation algorithm, where cluster heads are elected based on available energy. They suggest the design and prototyping of adaptive fidelity algorithms, where the fidelity of the retrieved data can be traded against energy efficiency, network lifetime and network bandwidth.

Fan Wen-You, Meng-Xin and Liu Xiao-Jing [22] explained the overall structure of forest fire monitoring system based on image analysis. The system includes three subsystems, which are the fire monitoring nodes based on image analysis, and remote monitoring terminal. It emphasizes the software and hardware realization of the fire monitoring nodes based on image analysis, address locators, on-site real-time monitoring under the coordination of the ARM system, GPRS module, GPS module and EVS100K camera module. The system uses the image analysis method as the early warning data of the fire monitoring system.

G.Zhang [23] compared with the traditional techniques of forest fire detection, a wireless sensor network paradigm based on a ZigBee technique was proposed. The architecture of a wireless sensor network for forest fire detection is described. The process of data transmission is discussed in detail environmental parameters such as temperature and humidity in the forest region can be monitored in real time.

D.Estrin and M.Srivastava [15] gives the explanation about the TinyOS which is perhaps the first operating system specifically designed for wireless sensor networks. TinyOS is based on an event-driven programming model instead of multithreading. TinyOS programs are composed of *event handlers* and *tasks* with run-to-completion semantics. Operating systems are often designed with real-time properties. Also the brief description of the components of OS is given in which the lowest-level components of OS, abstract the physical hardware and deliver physical interrupts as asynchronous events in which each application includes only the components it requires. Lite OS is a newly developed OS for wireless sensor networks, which provides UNIX-like abstraction and support for the C programming language. Contikiis an OS which uses a simpler programming style in C.

A. Awang, M. Suhaimi and H. Rimbamon [24] describes forests being an indispensable resource play an important role in maintaining the earth's ecological balance. Large scale deforestation has negative impact on the atmosphere resulting in global warming, flash floods, landslides, drought etc. Due to these adverse effects, forest management department all over the countries have taken steps for monitoring the forest to prevent deforestation. Surveillance plays an important role in forest management. Ground-based techniques generally include surveillance by on-site security staff and mobile patrols monitoring the property by water, land and air, All these systems are expensive and time consuming, requiring a lot of resources. Satellite imagery is very costly for use in monitoring any illegal activity like trespassers, tree theft and deforestation. With the technological advancements in wireless communication, various low power, and low cost, small-sized sensors nodes are available which can be readily deployed to monitor environment over vast areas. Wireless sensor network based surveillance systems for remote deployment and control are more cost effective and are easy to deploy at location of interest, WSNs finds immense application in land management, agriculture management, lake water quality management, forest fire detection, tree theft prevention and also in the prevention of deforestation.

C. Chong and S. Kumar [25] defined enhanced algorithm for continuous skyline computation in order to suppress collected data from wireless sensors that are monitoring environment for potential forest fires. In experimental evaluation, we showed that our approach is faster than other algorithms for continuous skyline computation over sliding windows. Because of the increased risk of forest fires in Croatia, especially during summer seasons, early detection and suppression of forest fires is crucial, in order to restrict their propagation. According to the Law of fire protection in the Republic of Croatia, National Protection and Rescue Directorate and its Fire Fighting Sector are obligated to propose Activity Program of special measures in fire protection on a yearly basis. One of the main goals of the program is development and implementation of new fire protection systems

Moore et al. [26] Forest fires are an important environmental problem. This paper describes a methodology for constructing an intelligent system which aims to support the human expert's decision making in fire control. The idea is based on first implementing a fire spread simulator and on searching for good decision policies by reinforcement learning (RL). RL algorithms optimize policies by letting the agents interact with the simulator and learn from their experiences.

The initial model describes the abstract mathematical problem of constructing a set of lines to minimize the size of an expanding stochastic process. It should be noted that this model also captures essential features of related problems such as the spreading of infectious diseases, flooding, fire outbreaks inside cities, and the spreading of violence or panic. They are able to find good team strategies for controlling forest fires in our initial model and make the model more complex by adding features which make the model more realistic. This will enable us to face the difficulties of realistic forest fires and to search for efficient ways for controlling them.

D. Krstini and D. Stipani [21] described precautionary measures to avoid a forest fire, early warning and immediate response to a fire breakout are the only ways to avoid great losses and environmental and cultural heritage damages. To this end, this paper aims to present a computer vision based algorithm for wildfire detection and a 3D fire propagation estimation system. The main detection algorithm is compose of four sub-algorithms detecting (i) slow moving objects, (ii) smoke-coloured regions, (iii) rising regions, and (iv) shadow regions. After detecting a wildfire, the main focus should be the estimation of its propagation direction and speed. If the model of the vegetation and other important parameters like wind speed, slope, aspect of the ground surface, etc. are known then the propagation of fire can be estimated. Early warning and immediate response to a fire breakout are the only ways to avoid great losses and environmental and cultural heritage damages. The most important goals in fire surveillance are quick and reliable detection and localization of the fire. It is much easier to suppress a fire when the starting location is known, and while it is in its early stages. Information about the progress of fire is also highly valuable for managing the fire during all its stages. The fire fighting staff can be guided on target to block the fire before it reaches cultural heritage sites and to suppress it quickly by utilizing the required fire fighting equipment and vehicles.

D. M. Doolin, N. Sitar and S. Glaser [13] described the design of a system for wildfire monitoring incorporating wireless sensors, and report results from field testing during prescribed test burns near San Francisco, California. The system is composed of environmental sensors collecting temperature, relative humidity and barometric pressure with an on-board GPS unit attached to a wireless, networked mote. Performance of the monitoring system during two prescribed burns at Pinole Point Regional Park is promising. Sensors within the burn zone recorded the passage of the flame front before being scorched, with temperature increasing, and barometric pressure and humidity. Temperature gradients up to 5 C per second were recorded. The data also show that the temperature slightly decreases and the relative humidity slightly increases from ambient values immediately preceding the flame front, indicating that locally significant weather conditions develop even during relatively cool, slow moving grass fires. The wireless sensor wildfire monitoring system represents a proof-of-concept implementation for wireless instrumentation in destructive, environmentally hostile wildfires.

E. Altman et al. [27]described smart environments represent the next evolutionary development step in building, utilities, industrial, home, shipboard, and transportation systems automation. Like any sentient organism, the smart environment relies first and foremost on sensory data. The challenges in the hierarchy of detecting the relevant quantities, monitoring and collecting the data, assessing and evaluating the information, formulating meaningful user displays, and performing decision-making and alarm functions are enormous. The information needed by smart environments is provided by Distributed Wireless Sensor Networks, which are responsible for sensing as well as for the first stages of the processing hierarchy. The importance of sensor networks is highlighted by the number of recent funding initiatives, including the DARPA SENSIT program, military programs, and NSF Program Announcements.

Milke and J.A [28] explained that early residential fire detection is important for prompt extinguishing and reducing damages and life losses. To detect fire, one or a combination of sensors and a detection algorithm are needed. The sensors might be part of a Wireless Sensor Network (WSN) or work independently. in the area of fire detection using WSN has paid little or no attention to investigate the optimal set of sensors as well as use of learning mechanisms and Artificial Intelligence(AI) techniques. They have only made some assumptions on what might be considered as appropriate sensor or an arbitrary AI technique has been used. By closing the gap between traditional fire detection techniques and modern wireless sensor network capabilities, in this paper they present a guideline on choosing the most optimal sensor combinations for accurate residential fire detection. Additionally, applicability of a Feed Forward Neural Network (FFNN) and Naïve Bayas Classifier is investigated and results in terms of detection rate.

E. Lafarge [29] analysed the effect of fire on a protected WSN. Because it is notpossible to follow the evolution of a fire with the current systems, we tried to provide a new solution to protect the sensors. The double system provides an adapted tool for natural fire scenarios. Results illustrate that the temperature and humidity variations in the socks allow us to relevantly determine the presence of a fire. If the response time is conveniently set up, i.e., sufficiently short in comparison to the shorter time scale of the fire, the WSN becomes a measurement system for the rate of fire spread in the open.

Alec Woo, Terence Tong and David E. Culler [30] described a system design approach for a wireless sensor network based application that is to be used to measure temperature and humidity as well as being fitted with a smoke detector. Such a device can be used as an early warning fire detection system in the area of a bush fire or endangered public infrastructure. Once the system has being developed, a mesh network topology will be implemented with the chosen microchip technology with the aim of developing a sophisticated mesh network. This paper fully describes, the domain problem as well giving an overall system design description, with a software simulation technique which will be used to demonstrate how data will rotate from one node or sensor to the other.

M.Zennaro, A.Bagula and B. Pehrson [31] explained that Wireless sensor networks appearing as consequences of the developments in wireless communication, micro-electro-mechanic systems technology and electronics have many promising application areas for the future. Forest fires are the disasters, which, cause loss of life, property, and destruction of thousands of hectares of forest land in the west and the south coastal zones of Turkey during the summer months every year. Technological requirements for Information and Communication technology projects to be applied successfully are defined as having connectivity, low cost, power efficient and having appropriate user interfaces, in the literature. Studies that indicate that the applications of wireless sensor networks are appropriate solutions for developing countries are also available. Also, the advantages and challenges in practice by the usage of wireless sensor networks in forest fires are pointed out.

S. Chen et al. [32] explained that Wireless Sensor Networks (WSN) allows large scale deployments for environmental monitoring applications especially in the Wild land Urban Interface (WUI) lands interface with homes, other. In such areas early fire detection is of great importance as the consequences of a fire are catastrophic. Towards this direction the SCIER1 project envisages the deployment of Wireless Sensor Networks at the WUI using a multi-level scheme of data fusion to enhance the performance of the early fire detection process.

Faouzi Derbel [33] described fire disaster is a great threat to lives and property. Automatic fire alarm system provides real-time surveillance, monitoring and automatic alarm. It sends early alarm when the fire occurs and helps to reduce the fire damage. Wireless sensor network has become the most important technology in environmental monitoring and home or factory automation in recent years. An automatic fire alarm system based on wireless sensor networks is developed, which is designed for high-rise buildings. In order to provide early extinguishing of a fire disaster, large numbers of detectors which periodically measure smoke concentration or temperature are deployed in buildings networks. Test results from the prototype system show that the automatic fire alarm system achieves the design requirements.

D. Steingart et al. [34] described fire fighting is one of the most important and risky professions in which people are employed. The dangers associated are the result of a number of factors such as lack of information regarding the location, size and spread of the fire. The use of wireless sensor networks may be one way of reducing the risks faced by the fire fighters and assist in the process of rapid extinguishment of the fire. In military applications, sensor networks now are widely deployed in diverse applications including home automation, building automation, and others. They present design and the implementation of wireless sensor network based fire monitoring and extinguishing system. Fire monitoring system continuously monitors the surroundings and keeps a track of the temperature recorded and the intruders detected, performed by monitoring node. Fire extinguishing system switches the extinguisher as soon as it detects the fire or when the temperature crosses a certain threshold level, performed by extinguishing node. Results indicate that the overall performance of the proposed approach is very good.

Meesookho, S. Narayanan and C. Raghavendra [35] explained wireless sensors and wireless sensor networks have come to the forefront of the scientific community recently. This is the consequence of engineering increasingly smaller sized devices, which enable many applications. The use of these sensors and the possibility of organizing them into networks have revealed many research issues and have highlighted new ways to cope with certain problems. In this paper, different applications areas where the use of such sensor networks has been proposed are surveyed.

R. Han, C. Seielstad and S. Holbrook [14] explained a cross-layering alarm application is proposed for supporting fire fighting operations. It runs on scattered wireless sensor networks (WSN) composed by several isolated WSNs, where sensor nodes can be destroyed by fire. Mobile patrol nodes deploy the alarm monitoring application and collect the alarm records, containing the set of sensor measurements above the threshold values. It uses a new Multimode Hybrid MAC, which can be controlled by the application. The application uses asynchronous mode when no alarms are active to optimise energy consumption; changes to full on mode to minimise delay during fire handling situations; and uses the synchronous mode during the transference of alarm records to the patrol node, balancing delay and energy saving. The alarm application organises sensor nodes into a clustered virtual overlay network and run a peer-to-peer searching service on top of it. This service is used to locate nodes outside the danger area, and to locate alarm records.

A. Khadivi and M. Hasler [36] explained the fire localization using a distributed consensus finding algorithm in a wireless sensor network is described. The fire is circumscribed by a circle. The information is available at all sensor nodes that are alive, which makes it robust against failures and losses. Minimizing energy consumption is crucial for sensor nodes that have to function autonomously as long as possible. The speed of convergence of the consensus finding algorithm has to be optimized. That optimizing, as is customary, the asymptotic speed of convergence is not the best method when a consensus value of low precision is sufficient. They have shown how to use a consensus algorithm for fire localization by circumscribing it by a circle. The centre and the radius of the circle are determined by repeated application of a distributed consensus algorithm. The information is made available at all sensor nodes that are still alive, which makes it robust against failures and losses. For energy conservation purposes, it is important to speed up the consensus finding algorithm. It is well known that this can be done by suitably weighting the edges of the network graph. However, They have pointed out that the usual solution that optimizes the asymptotic convergence rate may not be optimal when a low precision of the result is sufficient

Y. Zeng and C. Sreenan[37]explained Wireless Sensor Networks (WSNs) provide a low cost solution with respect to maintenance and installation and in particular, building refurbishment and retrofitting are easily accomplished viawireless technologies. Fire emergency detection and response for building environments is a novel application area for the deployment of wireless sensor networks. In such a critical environment, timely data acquisition, detection and response are needed for successful building automation. They presented an overview of our recent research activity in this area. Firstly They explained research on communication protocols that are suitable for this problem. Then they described work on the use of WSNs to improve fire evacuation and navigation.

Cui Li and J Hailing [38] described rapid development of sensors, microprocessors, and network technology, a reliable technological condition has been provided for our automatic real-time monitoring of forest fires control. They presents a new type of early warning systems which use a wireless sensor network to collect the information of forest fire-prone sections for forest fire, wireless sensor nodes constitute a "smart" monitoring and control network through the self-organization and transmits the messages to the control centre through the network, thus we can achieve the remote control of the forest fire.

Molla Shahadat Hossain Lipu et al. [39] explained a smoke detector or smoke alarm is a device that detects smoke and issues a alarm to alert nearby people that there is a potential fire. They can detect fire in their early stages and give you those precious minutes to enable you and your family to leave your house in safety. Wireless communication enables transfer of data or signals over part of the entire communication network. Wireless implementation of sensor network ensures safety in terms of saving lives and property. Wireless sensor network is realized using ARM 7 based microcontroller. When potential fire is detected, the smoke sensor sounds an alarm .It also transmits a signal wirelessly to other sensors in the network. The microcontrollers form the main unit of the system. It receives input from the sensors and wirelessly sends information to other sensors in the network to sound an alarm thereby preventing any disaster from occurring. Additional sensors and wireless nodes will be used to demonstrate the complete setup.

IV. Analysis of Utilization of WSN for Fire Control and Detection

Sensor nodes are usually scattered in a sensor field which is an area where the sensor nodes are deployed. Coordination among Sensor nodes is very important to produce high-quality information about physical environment responsible for fire outbreak [6].

4.1Finding: Wireless sensor networks for forest tree monitoring and alerting using rare event detection with ultra-low power consumption.

Flexibility: MAC protocols in WSNs generally are specific to the application. For instance, security is the primary goal for military applications like target acquisition, keeping a battlefield under supervision, intrusion detection, low-latency is the primary goal for healthcare applications like monitoring patients at hospitals, keeping seniors under supervision, and energy efficiency is the primary goal for some applications like monitoring an ecological region. Any MAC protocol that is developed should provide all of these attributes such as energy efficiency, low-latency, high efficiency and security. Although temperature sensors are probably the simplest and the most obvious sensors for fire detection, studying various sources in this field reveals that all researchers agree on the fact that it alone cannot accurately indicate fire and gas concentrations are main features for fire detection. Fire Weather Index (FWI) and other indices resulted from several decades of forestry research can be used as strong indications for forest fire detection. The WSN community needs to use the general knowledge about fire patterns, best combination of sensors and appropriate detection techniques from the fire-related disciplines. It is apparent that selection of sensors was often carried out randomly or assumption-basely.

***Wireless Technology*:** Cable is expensive, less flexible than RF coverage and is prone to damage. For new facilities, implementing a wireless infrastructure may be more cost effective than running cable through industrial environments, especially if the space M-Configuration may change to support different storage space allocation or flexible manufacturing stations. New sensors can be produced or existing sensors can be improved to increase robustness of the proposed system. New wireless technologies and new satellite tracking systems can be adapted to increase the efficiency of the system. Some studies on fire extinguishing such as using CO2 bombs at the access points for fire spread prevention can made. Sensors obtain environment information and collaborate among them to determine the current behaviour of the fire fronts.

Forest fires depend on three things: fuel, heat and oxygen. Taking away one of them will put out the fire. Methods for controlling the fire can be divided into airborne agents and ground agents. Airborne agents such as airplanes and helicopters drop water or chemical retardants in front of the fire and take away heat or oxygen. Ground agents such as trucks or land rovers are equipped with water tanks for directly attacking the fire. Other ground agents are bulldozers, tractors or people equipped with e.g. chain saws. These agents cut fire-lines, which is an effective means for removing fuel. The choice of methods and equipment which are actually used depends on the country and kind of environment.

Once a fire outbreak is signalled, the fire manager evaluates the situation and makes an initial attack plan to stop the spread of the fire. This plan consists of a number of fire-lines (sub-plans) which break the fire-propagation. Then they allocate resources from neighbouring resource bases to fulfil all sub-plans. Once the resources have started the fight, the field commander is in control. They coordinates the teams in the field and gets a stream of online information which enables him to re-evaluate plans constantly, e.g. if the situation gets too dangerous, he can choose to retreat.

4.2 Advantages of using Sensors for fire detection and control: The small and low cost sensors became technically and economically feasible nowadays [5].The sensing electronics measure ambient conditions related to the environment surrounding the sensor and transforms them into an electric signal. So utilisation of sensors for fire control and monitoring has following advantages:

- They are useful and can help security problems.
- They protect our valuables.
- It is used to detect light or temperature or smoke.
- It has high density of network nodes.
- Wireless sensor networks has to fast and accurately detect or predict the fire and send an alarm signal to the fire fighters as soon as possible.
- They control thing properly. e.g. control fire in library.
- It can accommodate new device at any time.
- It can give reliability of the solutions.
- It can make readings of fire detection more accurate.

4.3 Limitation of using sensors for Fire Control: Due to complexity and characteristics of wireless sensor networks, there are few limitation of using WSN for fire detection and control:

- They can easily be set off and cause problems.
- They can break down.
- They are expensive and self-heating.
- Locality: Each sensor has limited computing power, memory, and communication range, thus only a completely localized algorithm in Fire Net, where each sensor interacts with its neighbours only.
- Robustness: Sensors in Fire Net are working in a very harsh and highly failure-prone environment.
- WSN Lifetime: WSNs for wildfire monitoring are deployed in difficult to access areas the power source has to support the long –term operation of a sensor node.

4.4 Constraints in WSNs

The constraints in WSNs such as bandwidth, battery lifetime, processing capability and memory [40], there is a vital need for efficient transmission system for enhancement of quality of information. Fast data dissemination is need of sensors to transmit data to base station to provide quick response to users in emergency and disaster like situation. For nodes density, network size and topology, there is need of scalability also.

V. Conclusion and Future Work

Although some restrictions of Sensor Component are exposed in this paper, To guaranteed that the information produced through the sensor system is precise and correct, further research is essential. Additional research should also be carried out to decide the exact peak heat discharge rate of a fire. This can be possible with help of a full-scale burn test with reading of temperature and the smoke density. This information should be used in sensor component.

With the fire protection field evolving very fast, it can be expected that Sensor Component can be used extensively beyond the realm of fire protection [40,41]. Ther are constant sensor software updates due to growing awareness of sensor technology. but the limitations are still there in sensor softwares. Sensor Component is very helpful in modeling fume and hot gas progress. Through sustained utilization of the sensors, the complete restrictions and relevance of the sensor and software will be exposed in the near future, a fresh version of the sensors can be likely to be capable to represent all aspects of fire.

Acknowledgements

Authors would like to thank the researchers or academicians whose works have been cited in this paper. Authors are also grateful to Punjabi University Patiala for offering sufficient library and internet facility.

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