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SMART HOME MANAGEMENT SYSTEM FOR FIRE PREVENTATION THROUGH IOT SYSTEM

[1]Dr. Dattatray G. Takale, [2]Dr. Dattatray S. Galhe, [3]Dr. Parishit N. Mahalle, [4]Dr. Chitrakant O. Banchhor [5]Prof.Piyush P. Gawali, [6]Prof.Gopal Deshmukh, [7]Dr. Vajid Khan, [8]Prof. Madhuri Karnik

[1]Assistant Professor, Department of Computer Engineering, Vishwakarma Institute of information Technology, SPPU Pune

[2]Associate Professor, Department of Mechanical Engineering, Jaihind College of Engineering SPPU, Pune

[3]Professor and Head, Department of AI & DS, Vishwakarma Institute of information Technology, SPPU Pune

[4]Assistant Professor, Department of Computer Engineering, Vishwakarma Institute of information Technology, SPPU Pune

[5]Assistant Professor, Department of Computer Engineering, Vishwakarma Institute of information Technology, SPPU Pune

[6]Assistant Professor, Department of Computer Engineering, Vishwakarma Institute of information Technology, SPPU Pune

[7]Associate Professor, Department of Computer Engineering, KJ College of Engineering and Management Research, Pisoli, Pune

[8]Assistant Professor, Department of Computer Engineering, Vishwakarma Institute of information Technology, SPPU Pune

Email id: dattatray.takale@viit.ac.in

Abstract: The design and assessment of a wireless sensor network (WSN) for the early detection of home fires is the primary subject of the research article. By including a wide variety of sensors into the wireless sensor network, the authors tackle the important problem of providing prompt fire warnings. The wireless sensor network (WSN) is made up of minuscule, low-power sensor devices that are able to perceive their surroundings and give accurate, real-time fire detection. The authors suggest using the Global System for Mobile Communications (GSM) to minimize false alerts as a means of mitigating the effects of sensor failures. Simulations run in a language program and the Fire Dynamics Simulator are used to evaluate the results of tests designed to determine how well the fire detection system works. The findings indicate that the system is able to do early fire detection even when there isn't a sensor that's working properly, all while keeping the levels of energy usage within acceptable ranges. By facilitating the early identification and prevention of home fires, this study makes a contribution to the improvement of the overall safety of residential communities.

Keywords: WSN; smart homes; fire; multi-Sensor; GSM communication

I. INTRODUCTION

Incidents involving fire provide substantial dangers to both human lives and property, as well as to the natural environment. The traditional methods of fire control mainly depend on manual procedures and human interaction, which may cause delays in the detection, response, and mitigation of fires. On the other hand, the development of technology such as the Internet of Things (IoT) and big data analytics has opened the door to new possibilities for the revolutionization of fire management systems. There is the potential for a smart fire management system that makes use of devices based on the internet of things (IoT) and big data analytics to revolutionize fire prevention, detection, and response capabilities. Real-time data on environmental conditions, fire-related factors, and fire suppression methods may be gathered and evaluated if the system includes Internet of Things devices such as sensors, cameras, and actuators. This enables the system to collect real-time data[13].

The sample highlights the value of early fire detection in avoiding catastrophic losses. Installing a fire alarm system is recommended as a simple and efficient means of early fire detection. Heat, smoke, and gas detectors are just few of the components that make up a comprehensive fire alarm system[14]. Alarms may be set off automatically or manually when a fire is detected, drawing attention to the situation using lights and sounds including bells, sounders, and horns. This early notice gives people time to evacuate the area and put out the fire properly. The installation of a thorough fire alarm system is vital in reducing the damage caused by fires since it allows for rapid detection and response[15].

The WSNs may be used in fire detection and warning systems. Target tracking, localization, healthcare, smart transportation, environmental monitoring, and industrial automation are just some of the growing number of use cases for WSNs. WSNs use small, battery-powered sensor devices to keep an eye on things like humidity and temperature in order to aid with fire detection. The sensors signal the network when a fire-related event happens, such as the presence of smoke, heat, or gas[16]. When numerous sensors indicate a fire, the central node compiles the data and makes an assessment. Responses, from generating a fire alarm to more elaborate evacuation procedures, are planned in conjunction with a remote command center based on these inputs. Stand-alone WSNs and hybrid methods are only two of the many technologies based on WSNs that have been developed for fire detection. There are other event detection systems that can pick up on fire-related indicators including heat, gas, and smoke[17].

The problems of wireless sensor networks (WSNs) in smart homes and cities are discussed in this extract. High energy consumption due to communication overhead is a problem since it may quickly drain batteries and cause systems to crash. Each sensor in a smart home performs a particular task, so if one fails, the whole system might be compromised. If the sensor fails, it's possible that something is happening in that area that isn't being picked up[18]. Furthermore, single-purpose sensors increase the likelihood of false positives. If the temperature rises over a certain point, a heat detector could sound an alert, but that rise might be the result of natural phenomena or human interference. It is estimated that false alarms might cost between $30,000 and $50,000 each occurrence. Smart fire management systems based on WSNs will not function reliably and efficiently until these issues are resolved.

The critical need to strengthen fire preventive measures and increase safety in residential settings motivates research on IoT-based intelligent modeling of smart home environment for fire prevention and safety. House fires may have devastating results, involving death and destruction of property. To reduce these dangers and provide residents enough time to escape and put out the fire, early fire detection is essential. While fire alarm systems have shown to be useful, there is a rising need for even more cutting-edge, smarter systems that take use of the Internet of Things[19]. The goal of this study is to develop an IoT-enabled, intelligently modeled smart home environment capable of early detection of fire occurrences, reduction of false alarms, improvement of emergency response, and protection of occupants. The project intends to propose a novel solution to the urgent problems associated with fire prevention and safety in residential settings by merging IoT devices, wireless sensor networks, and data analytics[20].

Building an integrated system that makes use of IoT technology and intelligent modeling methods to improve fire prevention and safety in smart home settings is the goal of IoT-based intelligent modeling of smart home environment for fire prevention and safety[21]. The goal is to enable early fire incident detection using cutting-edge algorithms and sensors, optimize emergency response and evacuation protocols, reduce false alarms, maximize energy efficiency, and undertake stringent assessment and validation of the system's performance. The ultimate goal of this study is to develop a system that can efficiently detect fires in their early stages, reduce risks, and increase the well-being of smart home occupants[21].

The latest strategies for treating leaf diseases are discussed in depth in Session 2. The data utilized in this study is described in Section 3. In Section 4, we analyze the results of applying the proposed model to leaf samples with varying degrees of illness. The tree-leaf detection model is concluded in Section 5. The essay is concluded at Section 6.

II. RELATED WORK

A literature review on the identification of Smart Fire Management System Through IOT Based Big Data Analytics:

The authors of the 2019 article [1] "An IoT-enabled Big Data Analytics Framework for Fire Safety Management in Smart Buildings" (Zhang and Chen) set out to improve fire safety management in smart buildings via the integration of IoT and big data analytics. The authors suggest a complete system architecture that utilizes a wide range of Internet of Things (IoT) devices, including as sensors and actuators, to monitor and record environmental factors, fire-related metrics, and occupancy patterns in real time. Data mining and machine learning algorithms are used in the analysis of the gathered information to improve fire detection, risk assessment, and emergency response planning. The purpose of the framework is to facilitate effective resource allocation in fire safety management by increasing the rate of early fire detection and decreasing the number of false alarms. Insightful recommendations for improving fire safety management in the context of smart buildings are provided in this research.

Mehta, Kapoor, and Shetty's (2017) [2], "IoT-based Smart Fire Detection and Firefighting System using Big Data Analytics" describes a novel method for detecting and fighting fires that relies on Internet of Things (IoT) technology and big data analytics. The authors provide an architecture for a control system that takes into account sensors and cameras that are part of the Internet of Things. Cameras give visual input for situational awareness while sensors gather real-time data on fire-related aspects. In order to reliably identify fire occurrences and provide timely warnings, the gathered data is processed and analyzed using big data analytics methods. Optimal resource allocation and route planning are only two of the sophisticated algorithms included into the system. In this study, we show how combining IoT, big data analytics, and smart firefighting tactics may greatly enhance fire safety and response capabilities.

Sharma and Gupta's (2020)[3], research article "IoT and Big Data Analytics for Smart Fire Management in Industrial Environments" examines the use of these technologies to enhance fire control in manufacturing and other industrial settings. The authors provide a system that utilizes Internet of Things (IoT) devices and big data analytics strategies to improve industrial fire detection, prevention, and response. In order to monitor environmental factors, equipment health, and fire-related indicators in real time, the article covers the integration of numerous IoT sensors and devices. Big data analytics methods, including data mining and machine learning algorithms, are used to the gathered data in order to spot irregularities, forecast fire events, and allow preventative steps. The framework's intended results include increased fire safety in manufacturing settings via earlier fire detection and shorter reaction times. This study provides a glimpse into the future of smart fire control in factories, thanks to the Internet of Things and big data analytics.

An Internet of Things (IoT)[4] and big data analytics framework is presented in the research article "An IoT-based Big Data Analytics Framework for Smart Fire Management System" by Dhir, Gupta, and Choudhary (2019). This framework is intended to improve fire incident management. The authors suggest an architecture that incorporates sensors and actuators found in IoT devices into a unified network. Real-time data on fire-related factors is gathered by the IoT devices, and then processed and analyzed centrally using big data analytics methods. The framework uses machine learning techniques for fire detection, fire behavior prediction, and firefighting strategy optimization. It also includes a system for instantaneous monitoring, alarm generating, and crisis intervention. This study demonstrates how the suggested architecture improves fire control by making use of the Internet of Things and big data analytics.

According to the study[5] "Fire Safety Monitoring and Alert System using IoT and Big Data Analytics" by Hossain, Muhammad, and Mohammed (2021), this new method is made possible by combining IoT with big data analytics. This paper proposes a system architecture for monitoring and alerting on fire events that makes use of both Internet of Things sensors and big data analytics methods. Internet of Things (IoT) sensors and cameras monitor fire-related variables in real time, such as heat, smoke, and gas concentrations. Big data analytics methods are used to the gathered data for precise fire detection and quick alarm generation. Intelligent decision-making algorithms are also a part of the system, helping to make evacuation and reaction times more efficient. Using real-time monitoring, early detection, and proactive alarm systems, the article demonstrates how the suggested system improves fire safety.

The topic of study in[6] "Clustering and fault tolerance for target tracking using wireless sensor networks" by Bhatti, Xu, and Memon (2011) centers on the use of WSNs for monitoring moving targets. In order to improve fault tolerance in target tracking systems, the authors suggest a clustering-based strategy. In this research, we provide a clustering approach for organizing sensor nodes into clusters for more effective target tracking and sensing load distribution. The suggested method additionally deals with the problem of node failures by using redundancy and cluster reformation as fault tolerance strategies. The authors use simulations to test out the effectiveness of the suggested strategy and compare it to other approaches already in use. This research sheds light on how clustering and fault tolerance strategies might be used in WSNs to better monitor targets.

Research paper [7] "Exploiting IoT and big data analytics: Defining smart digital city using real-time urban data" by Rathore, Paul, Hong, Seo, Awan, and Saeed (2017) focuses on the application of IoT and big data analytics to the problem of defining smart digital cities. The authors suggest a system that makes use of urban data in real time to power smart city programs and services. They talk about how to incorporate Internet of Things (IoT) devices and sensors into a city's infrastructure to monitor things like traffic, energy use, trash management, and air quality. Insights for urban planning, resource management, and bettering the quality of life in cities may be gleaned from the processed and analyzed data utilizing big data analytics methods. Smart digital cities that are sustainable, efficient, and sensitive to the demands of their residents are the focus of this study, which demonstrates the possibilities of merging IoT with big data analytics.

Table 1: Comparative Study of Existing System

Research Paper	Methodology	Key Findings
Zhang, M., & Chen, M. (2019)	Proposed an IoT-enabled big data analytics framework	Improved fire safety management in smart buildings through real-time data analysis.
Mehta, N., Kapoor, R., & Shetty, S. (2017)	IoT-based smart fire detection and firefighting system	Enhanced fire detection accuracy and quick response using IoT devices and big data.
Sharma, R., & Gupta, D. (2020)	Utilized IoT and big data analytics for smart fire management	Proactive fire detection, risk assessment, and optimization of emergency response.
Dhir, V., Gupta, A., & Choudhary, S. (2019)	Proposed an IoT-based big data analytics framework	Improved fire management through real-time monitoring, detection, and emergency response.
Hossain, M. S., Muhammad, G., & Mohammed, S. S. (2021)	Developed a fire safety monitoring and alert system	Real-time fire monitoring and timely alerts using IoT and big data analytics.

The creation of adaptable and intelligent fire prediction models is an area of study need in the field of Smart Fire Management System using IoT-based Big Data Analytics. There is a need to investigate sophisticated machine learning approaches that can assess historical fire data in addition to real-time sensor data to forecast fire occurrences with improved accuracy and early warning. Previous studies have concentrated on real-time fire detection and emergency response. Predictive models may be educated using big data analytics to learn to recognize trends, correlations, and risk factors that lead to fire outbreaks. The system's forecasting skills may be further improved by factoring in dynamic aspects like weather, building materials, and occupancy patterns [20]. The proactive actions and resource allocation necessary to reduce the likelihood of fires may be greatly enhanced by the findings and implementation of such adaptive and intelligent fire prediction models[21].

III. PROPOSED WORK

In this section of the article, we will split down our task into its four component sections, each of which is responsible for a distinct operation inside our system. The first section is dedicated to the sensor, which is in charge of gathering data from its surrounding environment. Utilizing the ZigBee protocol, the data that has been gathered is then sent on to the second unit, which is referred to as the processing unit. The third unit is specifically designed for GSM connectivity, which guarantees that users will get timely warnings in the event that a fire is detected in the building. Last but not least, the fourth unit is in charge of sounding the alarm and informing everyone that there is a fire in the building. In order to improve fire safety and prevention in the context of smart homes, the operation of our system as a whole depends on the contributions made by each individual unit. These contributions include efficient data collecting, processing, communication, and alarm systems.

The Existing fire detection systems have limitations since they rely on single sensors that only perform one function for each residential target area. This makes them less effective than they might be. These systems have difficulties in recognizing events when a sensor in a particular location is not functioning properly, which makes it difficult to detect fires in the early phases of their development. The activation of false alarms, which may result in unwarranted anxiety and disturbances, is another problem that has to be addressed. The sensor unit, processor unit, GSM communication system, and alarm system are the four key components that make up the proposed smart home fire detection system. This was done in order to overcome the shortcomings that were mentioned before. The sensor unit incorporates multisensory that are placed in each section of the smart home, such as smoke, gas, and heat sensors. These sensors each have their own method for detecting events that have occurred. The ZigBee Protocol is used for communication between the sensors and the home sink, which is a component of the processing unit. The fire detection choices made by the sink are based on the information received from the sensors as well as the replies from the users. The GSM communication system is engaged as soon as it receives a fire alarm from even a single sensor node. This causes an alert message to be sent to the user. Before sounding an alarm, the sink does further analysis on the data collected from a number of sensors or requests confirmation from the user. In addition, the system communicates information about events to both the cloud and a local server. The local server then communicates the information to basic service units and alerts people living in the nearby area about the issue. The information on each unit's specific design may be found in the following subsections.

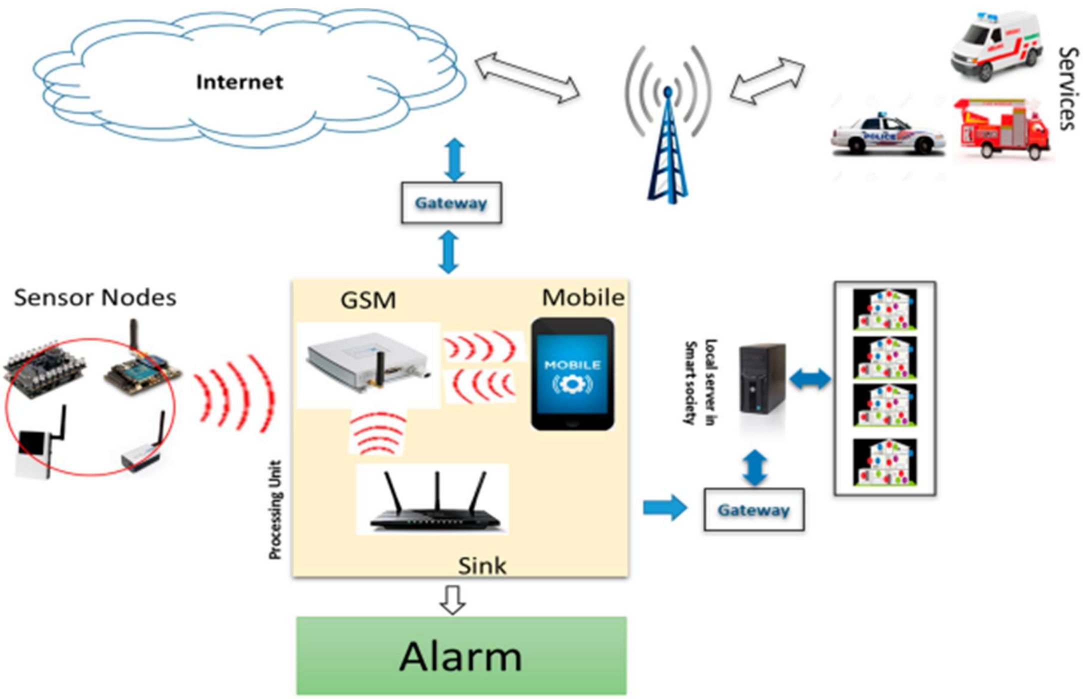

Figure1: IoT-based intelligent modeling of smart home for fire prevention

For the purpose of identifying shifts that may be connected to fire occurrences, our model makes use of smoke, gas, and heat sensors. These sensors were developed to identify the byproducts of a fire, such as heat, smoke, gas, and infrared as well as UV radiations. The smoke sensors are able to detect variations in smoke density, while the gas sensors are able to detect variations in gas levels that may signal the existence of a fire. The smoke sensors are especially intended to detect changes in smoke density. In addition, we make use of temperature sensors that can be split into two distinct categories, based on the way in which they function: (i) rising rate of heat detection, in which the sensors identify sudden spikes in temperature; and (ii) fixed temperature detection, in which the sensors issue warnings when a predetermined temperature threshold is reached. Our model intends to improve the precision and efficiency of fire detection in settings consisting of smart homes by making use of a variety of these sensors in conjunction with one another.

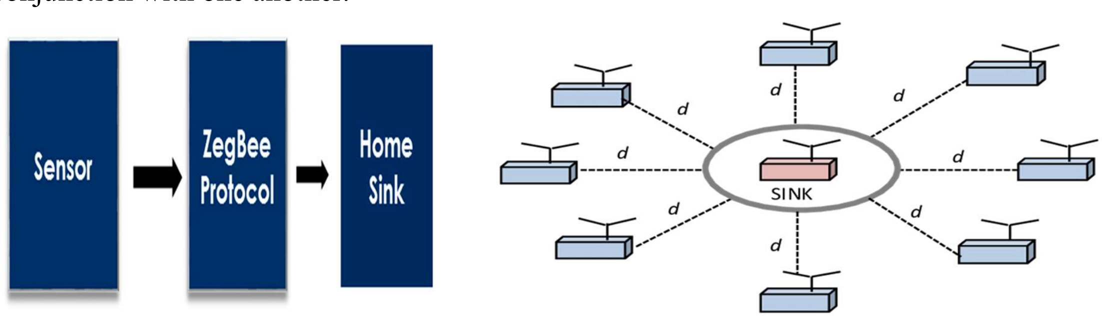

Figure 2: Flow diagram of the Wireless Sensor Node & Star topology

The ZigBee protocol is well-known for its low overall power consumption, with the transmission of data accounting for the bulk of the protocol's overall power requirements. The protocol makes use of many various kinds of devices, such as coordinators, routers, and end devices, among others. ZigBee's method of encoding is referred to as direct sequence spread spectrum, or DSSS for short. It is capable of functioning in either of two major communication modes: beacon-enabled or beacon-disabled. In a communication system that makes use of beacons, the PAN (Personal Area Network) coordinator will, at regular intervals, broadcast beacon frames or packets. During communication that does not use beacons; the PAN coordinator will broadcast beacon packets in a random order. When sensors are not actively collecting or sending data, the protocol will switch off its interface automatically in order to save power whenever this condition occurs. However, the nodes continue to operate in an active state even while beacon messages are being sent. The beacon intervals commonly fall anywhere between 15.36 and 251.65 milliseconds, with the exact value being determined by the data flow rate as well as the transmission speed of 250 kilobits per second. ZigBee was chosen as the protocol for data transfer in our smart home fire detection system because of its energy-saving capabilities and its communication style.

IV. RESULT ANALYSIS

During the simulation of our smart home fire detection system, we configured the sensors with their corresponding threshold values and added the GSM module in order to avoid false alarms from being triggered. When the readings of two or more sensors surpass their threshold values, the system will sound an alert. If the user also certifies that there was a fire, the system will also sound an alarm. In order to guarantee the dependability of the system, we carried out a series of tests, and the findings showed that there was an almost nonexistent incidence of false alarms. We compared the results of the simulation we ran with the results we got from using methods that are already in use in order to determine how effective our suggested strategy is. Because of this comparison, we were able to discover that our technology is very effective in terms of detecting and preventing fires. In the sections that follow, we will show and discuss the specific outcomes of our simulated trials.

In this work, we explain an issue, and to solve it, we performed simulations of two alternative situations. This allowed us to compare the behavior of sensors and address the problem. To begin, we ran a simulation of a scenario with a single sensor. In this scenario, a temperature sensor was installed in every section of the smart house. Second, we put into action the multi-sensor environment that was suggested in our previous study. Two different kinds of datasets were produced as a result of these simulations: (i) data from the single-sensor scenario, and (ii) data from the multi-sensor scenario. Using these datasets, we conducted an analysis on the behavior of the sensors. In the scenario with a single sensor, we speculated that the fire started in the kitchen, so we deactivated the sensor that was located in the kitchen so that we could study how the other sensors responded. Figure 10 is an illustration of the behavior of the sensors while running a simulation with a single, unifunctional sensor. During the whole blaze, we found that the sensor in the kitchen did not respond to our commands. After eight, fourteen, and eighteen minutes, respectively, the additional sensors that were installed in the TV lounge, living room, and bedroom began registering a rise in temperature as the fire and heat moved across the space.

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