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SENSOR NETWORK SOLUTIONS FOR AIRCRAFT ROUTE SCHEDULING AND PARKING ALLOCATION WITH LOCALIZATION AND SYNCHRONIZATION

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Abstract. The Wireless Sensor Network (WSN) is the modernized version of the sensor networking, earlier the concerned networking system used to be wired. The wireless and modified features have been able to increase the efficiencies of the networking in routing scheduling of aircraft and allocating the parking. This new approach to the WSN system is not much different from the typical sensor networks framework that contains sensors, a communication system, and a controller. Instead of a communication system, a wireless protocol is applied within the sensor network. The smart system of parking has effectively implied due to its hugely innovative as well as in-ground sensors. This can monitor individual spaces of parking and able to relay the status of occupancy to the smart-sport gateways. Then, this can send the live status data to the platform of the smart cloud. This entire process enables the real-time parking data to be accessed and observed on multiple devices.

Key words: Sensor Network, Wireless Sensor Network (WSN), Aircraft Route Scheduling, Parking Allocation, Localization and Synchronization

1. Introduction. The sensor network constitutes a set of small and powered devices along with the infrastructure of both wired and wireless networks. These groups are able to record conditions following any number of environments such as farms, hospitals, and industrial facilities [21]. For vehicles and transportation systems, the use of sensor networks has been seen in the route scheduling of aircraft and in parking allocation systems for localizing and synchronizing.

From the above-presented diagrammatic representation 1.1, the versatile uses of Wireless Sensor Networking (WSN) are reflected [15]. The mentioned security and surveillance and tracking vehicles are widely used for traffic control and monitoring for land and air vehicles as well. In terms of aircraft scheduling, earlier approximately 80 percent of flight accidents were caused by machines, and nearly 20 percent of accidents happened due to human errors. The implementation of WSN in aircraft is one of the reasons behind the improved technological aspects to reduce system and machine failures [12]. Hence, today the scenario has changed entirely, nearly 80 percent of aero plane accidents occur due to human errors such as mechanics, controllers, pilots, and so on whereas machine or equipment failures related accidents are 20 percent. The major contribution of the work is as follows,

1. **Transition to Wireless Sensor Networks (WSN):** The research addresses the transition from traditional wired sensor networks to Wireless Sensor Networks (WSN). This shift reflects the advancement in technology, offering increased flexibility and efficiency in various applications.
2. **Efficient Routing Scheduling for Aircraft:** The research introduces the concept of using WSN for routing scheduling of aircraft. This innovation demonstrates the potential to enhance the management and efficiency of aircraft movements within airport premises.
3. **Parking Allocation Optimization:** The study explores the application of WSN in allocating parking spaces, particularly in the context of aircraft. This novel approach can lead to more efficient parking allocation, reducing congestion and optimizing resource utilization.
4. **In-Ground Sensor Implementation:** The research presents the innovative use of in-ground sensors for monitoring individual parking spaces. This implementation has the potential to revolutionize parking management by providing accurate real-time occupancy status.

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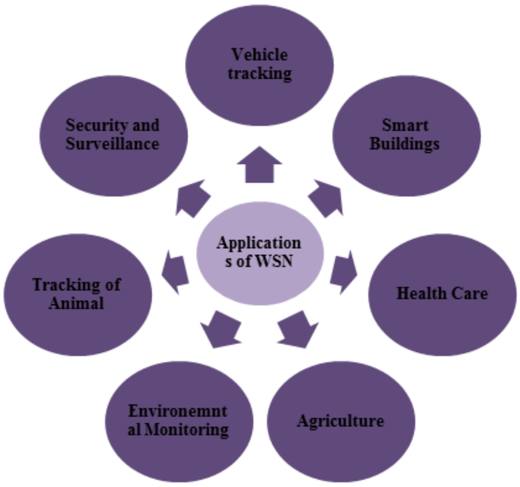

Fig. 1.1: Applications of Wireless Sensor Networks (WSN)

5. **Smart Sport Gateways Integration:** The research integrates the concept of smart sport gateways, acting as intermediaries between the in-ground sensors and the cloud platform. This integration demonstrates a holistic approach to data relay and connectivity.
6. **Real-time Parking Data:** By utilizing WSN and in-ground sensors, the research achieves the capability to gather real-time parking occupancy data. This data can be accessed by various devices, enabling users to make informed parking decisions on the go.
7. **Cloud-based Data Platform:** The study introduces the usage of a smart cloud platform to aggregate and manage the real-time parking data. This cloud-based approach enhances data accessibility, analysis, and utilization.
8. **Multi-Device Observability:** The research offers multi-device observability of real-time parking data, allowing users to access this information through different devices such as smartphones, tablets, and computers.
9. **Integration of Multiple Technologies:** The study showcases the integration of various technologies, including WSN, in-ground sensors, smart sport gateways, and cloud computing. This multidisciplinary approach demonstrates the research's innovative nature.
10. **Practical Implementation Potential:** The research's findings highlight the potential practical implementation of a smart parking system based on WSN. This has implications for modernizing parking management strategies in various domains.
11. **Data Accessibility and User Convenience:** The research contributes to the ease of access to real-time parking data, enhancing user convenience and potentially reducing congestion through more informed parking decisions.

The research introduces a novel approach to networking by applying Wireless Sensor Networks to optimize aircraft routing scheduling and parking allocation. The integration of in-ground sensors, smart sport gateways, and cloud-based platforms further enhances the capabilities of the proposed system. This innovative research opens up opportunities for more efficient and smart parking management systems, while also showcasing the potential of WSN in broader applications.

2. Objectives. The main objective of the research is to explore and demonstrate the potential benefits and practical implementation of using Wireless Sensor Networks (WSN) in optimizing aircraft routing scheduling and parking allocation. The research aims to showcase the innovative application of WSN technology and its integration with in-ground sensors, smart sport gateways, and cloud-based platforms to create a smart parking management system.

Fig. 3.1: The way of conducting Secondary research

1. To define the sensor networks for aircraft route scheduling and parking allocation with localization and synchronization
2. To find out the significance of the sensor networks
3. To detect the risk of using sensor networks in scheduling the aircraft route and localizing and synchronizing the parking route
4. To determine the potential solutions to the threats of using sensor networks
5. To analyze the architecture of the sensor networks
6. To evaluate the application of sensor networks in advanced technology

3. Methodology. A secondary qualitative research method has been applied here to find out the solutions and usage of sensor networking in terms of route scheduling of aircraft and synchronizing and localizing the parking [2]. Following this, secondary research can be described as the method of using data that already exists which can be from research articles of other researchers, books, published academic papers, statistical databases, and so on.

In the above-presented figure 3.1, the way of conducting secondary research has been presented [23]. Sensor networks and their uses in aircraft and parking have been identified as the topic. The data sources of the concerned research topic have been identified and acquired from other research articles, statistical databases, and so on. Qualitative research has been carried out on the collected secondary data that is used to explore and get deeper insights into the issues of the real-world such as sensor networking [25]. Unlike the quantitative data, the qualitative research did not collect numerical data, it helped to generate hypotheses and further research and comprehend the quantitative data research.

4. Discussion on Sensor Netwwork. Due to the technical improvements and modifications of nodes, the use of WSN has increased and is used mostly than wired sensor networks in aircraft and traffic [10]. The data rate of wireless sensor networking (WSN) ranges between 80 kb/s - 250 kb/s for operating in different areas.

The aforementioned Figure 4.1 has described that with the support of the internet, the WSN is integrated into the aircraft and traffic system in order to carry out the analysis, storage, mining, and processing. This is done through its sensors, which, lead to two sensing regions mentioned in the figure. It connects the base station with the sensors so that the data can be transcended and accessed in real time.

The aforementioned Table 4.1 described thoroughly the applications of sensor networking in aircraft and traffic [3]. In this regard, for aircraft, the use of the wireless system in sensor networking has been seen as it is more beneficial and less complicated than the wired system.

5. Impact of Sensor Networking for Aircraft Route Scheduling and Parking Allocation. Table 5.1 in the above presentation discussed several activities of sensors in the context of parking allocation [16]. The synchronization phase within two nodes is seen to be a two-way communication.

The above-presented diagrammatic representation 4 has depicted the two-way communication within nodes. Along with this, the synchronization phase continued with the sender-to-receiver communication [1]. In parking allocation, the movement can be located and synchronized by commencing with the root node and propagating

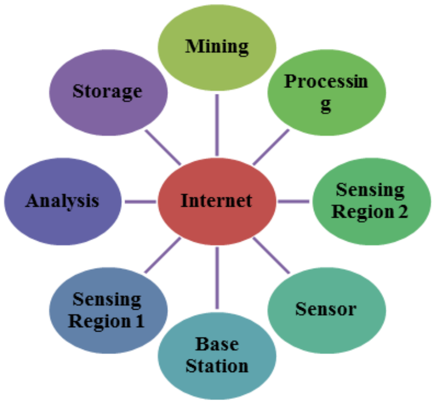

Fig. 4.1: Process and Components of WSN used for aircraft and traffic

Table 4.1: Use of WSN in aircraft and parking

Route Scheduling of Aircraft	**Localizing and Synchronizing the Parking**
Recently, the airplane monitoring system (AMS) has integrated the airborne wireless sensor networks (AWSN) to leverage the advantage, especially flexibility.	It is seen that the activity of detecting sensor nodes' physical coordinates within WSNs is known as positioning or localizing. This is considered as the key aspect in the current system of communication so that the estimation and measures can be taken regarding the place of origin of incidents.
The easy deployment system and the low-cost nature of the concerned system have made it beneficial to implement in the aircraft.	The inductive detector of the loop (ILD) sensor is acknowledged as the most commonly used sensor in terms of traffic management.
The new approach of monitoring the aircraft through the AWSN resolves many issues of wire-based tools like the efficiency of fuel, emission of carbon, and mass of flight.	Sensor networking is used for acquiring the flow of traffic, occupancy of vehicles, length, and speed.

through the network [5]. In this regard, it can be stated that the parking sensors are acknowledged as proximity sensors [9]. This is being used for designing road vehicles so that the drivers can stay alert about the obstacles of parking.

On the other hand, in terms of Aircraft Route Scheduling, the travel route scheduling schema with the mobile collector (TRP-MC) can be possible [6]. It considers a short route which can take as many sensors of AWSNs as possible [14]. In this regard, the communication system of the concerned AWSN can be used.

In the above-presented diagrammatic representation, it is reflected that the concerned communication of AWSN consists of four components, which are beyond AWSN, smart sensors, inter-AWSN, and remote servers [13]. Hence, the smart sensors within the AWSN networking can be deployed on the airplane so that the connection can be made through the AWSN. It can be stated that among all the sensor nodes, the AWSN is dependent on wireless transceivers [20]. It is because the beyond AWSN component along with the access point nodes and the gateway forms a bridge to other networks in airplanes such as portable devices, displayers in the cockpit, and system of control [17]. In this regard, it has been seen that the higher-level implementation of data is entirely based on the concerned sensory networking. The networking of satellites, ground stations, the centre of air traffic control, and the system of management all are involved in the higher level of applying data.

Table 5.1: Traffic activities by sensors

Synchronization of Traffic and Parking Allocation	**Use of sensors**
Traffic light sensors	In the traffic sensor context, the traffic light or intersection needs to be placed once, then the sensor can be able to determine the vehicle in different areas which are predefined. This would help in allocating the parking as well. After that, this is able to activate one or many relays. These relays are responsible for triggering the traffic light to be red or green.
Vehicle movement sensors	For the detection of vehicle movement, a radar antenna is equipped with a sensor of the traffic light. The movement of vehicles can determine the allocation in the smart parking system.
Localization of Nodes	Localization of the concerned sensor nodes within the WSNs is seen to be serving a significant role in monitoring the traffic. In this regard, the main aim of the localization process is to seek the coordinates of all targeted nodes through their connection with the anchor nodes. In this way, the vehicle movement can be detected by the sensor networking in traffic and verifying particular vehicles if required.

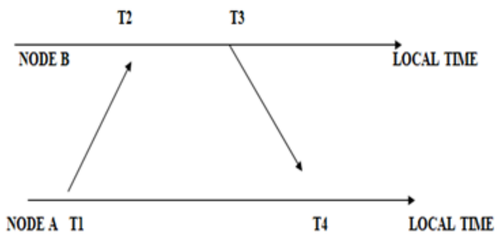

Fig. 5.1: The two-way communication between nodes in the synchronization phase

6. Potential Risks of using Sensor Networking. There are certain disadvantages to using sensor networking that poses threats in the fields the WSNs are being used. Generally, the range of WSNs is acknowledged as limited according to their design [19]. The concerned sensors are designed to work over a few hundred meters at most. Hence, if routing and scheduling for aircraft or localization and synchronizing the traffic are required to get coverage of a larger area, the WSN would fail. The use of multiple sensors can temporarily solve the issue; however, it is extremely expensive and too complicated to manage [27]. In addition, the dependence on wireless communication, the WSN is considered to be highly susceptible to interference with other devices. This can turn out to be extremely dangerous for any transportation from aircraft to road traffic. The loss of data or data corruption can happen, and even the performance of the network can get affected entirely.

The above-presented Table 6.1 discussed the issues caused by WSN to aircraft routing [7]. It is seen to be difficult to plan a reasonable route of travelling in terms of acquiring data efficiently [28]. This concerned issue is affecting people to plan a travel route without any inconvenience of scheduling other places.

7. Possible Solutions to the Threats. There might be certain disadvantages of WSN, however, the issues can be solved and the advantages of the WSN can be able to create balance to reduce the extremeness of these issues.

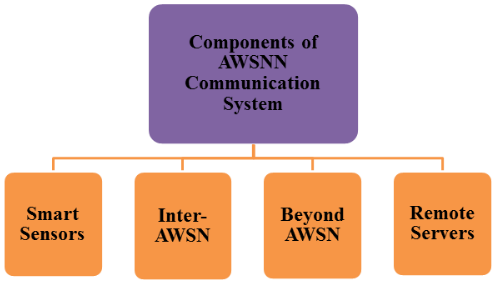

Fig. 5.2: The components of AWSN communication system

Table 6.1: Risks in Routing due to sensor networking and its design

Challenges of routing and issues in the design of WSN	**Description**
Deployment of nodes	The deployment of nodes in the WSNs is seen to be dependent on the application. This application-centric nature can potentially affect the routing protocol performance.
Considerations of energy	The sensor nodes might consume all the limited supply of energy, which is allocated for performance consumption, and transmission of information in the wireless environment.
The delivery model of data	The data delivery model is driven by events. Hence, it is prone to react immediately due to any sudden and drastic changes.

Table 7.1 has reflected the potential solutions to the rising threats from the WSNs application. In this regard, it is seen that the system is much more cost-effective than the previous wired system [11]. However, the multiple expansions can cost more in WSN, which is still effective for the budget as the initial cost was low. In addition, it would require only an operator to handle the delivered data and a technical expert to manage the entire network [29]. Therefore, the low maintenance of the concerned system makes it more effective. In terms of parking allocation, the use of electromagnetic or ultrasonic sensors has been observed in recent times. This is an extremely cost-effective and scalable system than the previously used wired networking.

8. Architecture of Sensor Networks. The sensor network is seen to contain numerous sensor nodes that are detection stations. These nodes are small, portable, and lightweight, and each is equipped with a transducer, transceiver, microcomputer, and power source [2]. This aforementioned transducer produces electrical signals, which rely on sensed physical effects and phenomena.

The block diagram of a sensor node has been depicted in the above-presented Figure 8.1 [18]. From the diagram, it can be assessed that a modular design approach of each sensor node offers much-needed flexibility as well as versatility in the concerned platforms such as aircraft and parking allocation. Through this, the requirements of a large variety of implementations can be possible [9]. The parking allocation of sensor networking is capable of handling the traffic, generating the signals according to the vehicle movement, allocating the appropriate parking to vehicles, and localizing, and synchronizing the allocation to enhance the smart parking and traffic system entirely.

9. Sensor Networking and its Use in Advanced Technology. The above-presented Table 9.1 has shown the integration of different advanced technologies with the sensor nodes of WSNs to enhance the smart parking and aircraft system [11].

Table 7.1: Potential effectiveness of WSN

Factors	Description
Energy efficiency	In terms of energy consumption, it is seen that the WSN is a new approach, which apparently consumes less energy than the traditional wired system. The battery-operative WSN system and lack of physical connections in the modernized WSN networking trigger the lesser consumption, which can be modified further targeting the zero consumption of energy.
Cost-effectiveness	It is seen to be less expensive to implement the WSN networking than the previous wired networking system. Installing the wired system would cost a lot more than inserting the WSN system. Through this concerned cost-effective process, the flexibility has increased a lot.
Scalability	The scalability of the concerned WSN system is huge and it can be expanded by adding more sensors within the structure of the network. Therefore, it is the enabler of investigating a larger area more than its limited expansion range and more events can be detected through this.

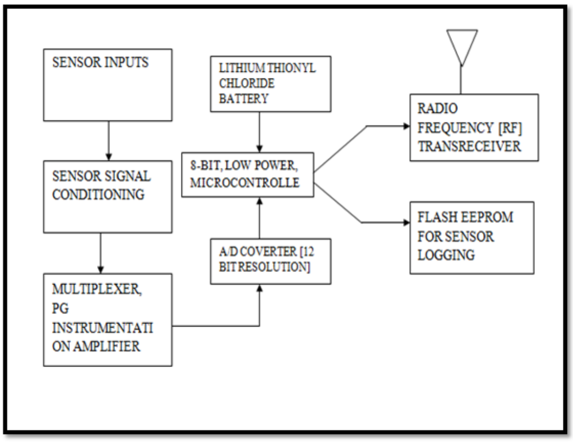

Fig. 8.1: A sensor node's functional block diagram

Table 9.1: Integration with advanced technologies

Technologies	Integration with sensory network
AI	It is seen that the combination of multiple sensors enables an AI-driven robot to detect the size, recognize an object, and locate its distance. On the other hand, AI technology can be potentially applied to detect the hidden risks of WSNs networking. The prevention of certain undetected security threats of WSNs can be resolved through the integration of AI technology.
IoT	The integration of WSNs in IoT can be able to create an infrastructure-less wireless network. This can be utilized in the deployment of a large number of wireless sensors, which can monitor the system to appropriately carry out the parking allocation as well as an aircraft routing system. Certain physical and environmental situations are also deployed through this.

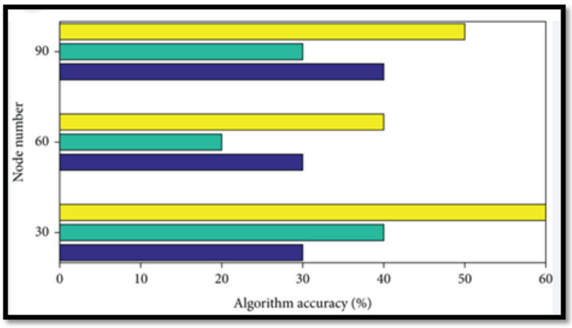

Fig. 10.1: Node number and algorithm accuracy

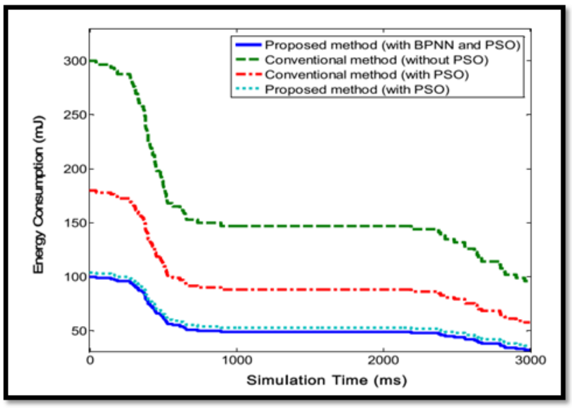

Fig. 10.2: Consumption of energy and simulation of time

10. Results. Sensor networking technology has an immense effect on controlling the routes of traffic for aircraft. In terms of efficiency and productivity increase the wireless networking system has been proven useful in sectors like parking of cars, buildings made with smart technology, health care sectors, agricultural field, monitoring of environmental issues and animal tracking.

From the figure 10.1 it can be seen that different networking signals have been colour-coded here as blue for DCCS, green for DMC-CS and yellow for EDACP-CS. These signals have been compared for their accuracy of algorithms in percentage and number of nodes [4]. For node numbers 0 to 30 or 40 the accuracy of signals is found to be 30% for DCCS, 40% for DMC-CS and 60% for EDACP-CS. The percentage values of algorithm accuracy range from 20%, 30% and 50% for node numbers varying between 45 and 75. 60 is the average node number in between and EDCAP-CS shows the maximum accuracy value and DMC-CS shows the lowest accuracy value [8]. For several nodes varying between 75 to 105 accuracy values of the algorithm varies in between 50%, 30% and 40% for three types of signals. Here also it can be seen that the highest accuracy value is seen for EDACP-CS and the lowest value of accuracy is seen for DMC-CS. From this analysis, it can be effectively concluded that for traffic signal controlling EDACP-CS signal is the most efficient as it has the most accuracy of the algorithm and DMC-CS is the least efficient network signalling method because it has the lowest number for accuracy of algorithm per number of nodes [15]. These signals are frequently used in controlling network traffic for air routes and other vehicles. In the case of air traffic controls the placed methods are highly effective when the accuracy of the algorithm is higher.

The figure 10.2 depicted above represents a stimulation of the consumption of energy and time required for the stimulation. The experiment is done to analyze and compare energy consumption in a particular period. The results of the simulation experiments are generally verified over data collected from over 1000 stimulations [22]. The obtained data from the stimulation experiments have been analyzed and transformed into graphical forms. The data is observed and analyzed by keeping about the mathematical deviations and optimal calculations. The figure illustrates the relationship between energy expenditure in a given fixed period. As evident from the graph, it can be clearly stated that with the increase in the total number of stimulations, the consumption of energy has decreased for all the involved systems [24]. It can be said that in general terms equally distanced nodes with conventional usage with PSO use more energy as compared to BPNN and PSO which consumes 100 mJ in over 3000 ms this is because of the back propagation phenomenon. Conventional methods of the depiction of models of stimulation show more usage and consumption of energy in values of 300 mJ in 3000 ms. The same conventional methods use very less amount of energy when used in conjunction with PSO. The accuracy of energy models is summed up by the more efficient energy usage and efficiency [26]. The model of the hybrid approach has been phenomenal and most efficient in terms of energy and productivity. More energy consumption would indicate more wastage of resources which will not be beneficial in the long run. That is why it is more efficient and productive than BPNN and PSO methods used to modify the proposed methods.

11. Problem Statement. The sensor network is a significant solution to managing the aircraft route schedule as well as the allocation of parking, however, recently it is facing certain problems. This should be acknowledged as early as possible to modify the system and improve it more than earlier to be more effective. Some nodes of sensors are seen to be either failed or blocked because of damage physically, lack of power, or interference from environmental factors [7]. Only rerouting or actively adjusting powers of transmission are the only ways to handle this fault tolerance issue. However, this is decreasing the performance and productivity for routing the aircraft or allocating the parking.

12. Conclusion. The primary significance of using the wireless sensor network lies in generating authentic real-time data in each field. The aviation system and smart parking allocation matter are two important fields where the inclusion of the WSN has immensely improved the field. The data collected through concerned sensor networking can be evaluated and utilized by connecting it to the internet or the computer network. Considering the advancement of technologies in this modern era, the importance of sensors in WSNs has increased everywhere, especially in environments, phones, workplaces, and vehicles. One of the primary takeaways from this study is the remarkable role that WSN plays in ensuring the generation of accurate and real-time data. In the aviation sector, for instance, the implementation of WSN facilitates more precise and efficient aircraft routing scheduling. Real-time data collected from sensors placed at strategic points can be harnessed to monitor the movement and status of aircraft, enabling optimization of routes and schedules. This not only enhances operational efficiency but also contributes to overall safety and better resource utilization within airport premises.

Similarly, the realm of smart parking allocation has been revolutionized by the integration of WSN technology. The utilization of in-ground sensors to monitor individual parking spaces enables the continuous tracking of occupancy status. By relaying this information to smart sport gateways and ultimately to cloud platforms, users gain access to real-time parking availability updates. This not only streamlines the parking experience for users but also offers opportunities for effective parking space management, reducing congestion, and optimizing space utilization.

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