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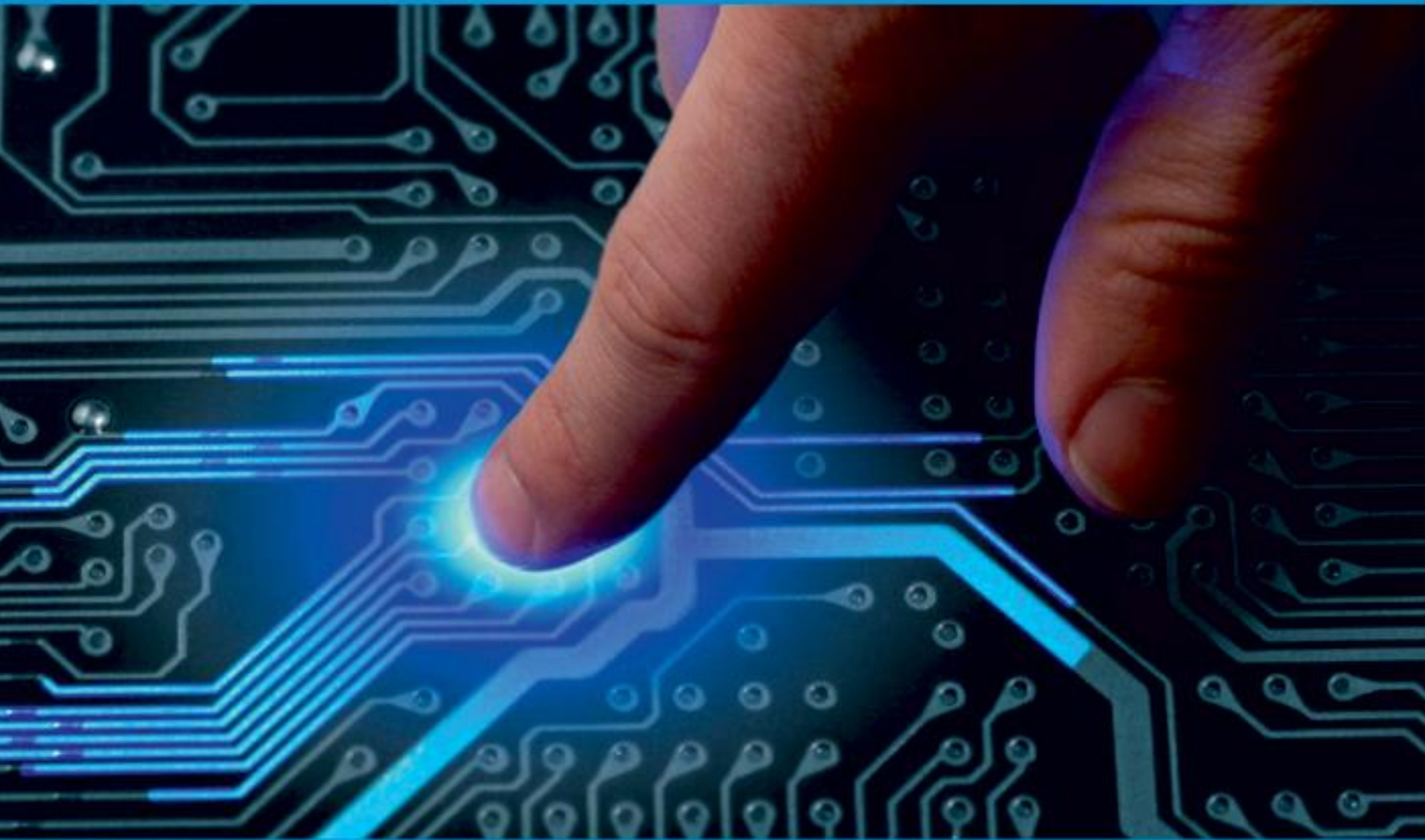

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Reinforcement Learning-Based Emergency Response Routing Protocol for Smart Buildings

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ABSTRACT: The Internet of Things (IoT) makes extensive use of the IPv6 routing protocol for low-power and lossy networks (RPL). However, there isn't yet a fire-related real-time effective routing protocol based on RPL. IoT devices commonly breakdown in sensor networks during fire catastrophes, which leads to fluctuations in the RPL graph. This work suggests an emergency RPL to efficiently forecast the spread of the fire and transmit sensor data in the event of a fire in real time. The packet delivery ratio is markedly increased when EMRPL is compared to RPL. This demonstrates that EMRPL is more efficient and that it may be used successfully in fire events.

KEYWORDS: Internet of Things, Reinforcement Learning, routing protocol, RPL.

I. INTRODUCTION

The process of connecting two or more computing devices in order to share data is known as networking. Networks are made using computer hardware and software. The protocol alludes to the networking-specific computer device communication language. Computer networks can also be categorized based on the set of protocols they support. In networks, generally, to accommodate multiple applications, use a variety of protocols. On the internet and in domestic networks, TCP/IP, one of the most popular protocols, is the most widely utilized. When no wireless access points are present, the well-known IEEE 802.11 ("Wi-Fi") wireless technology integrates an ad-hoc networking system, however, it is regarded as a somewhat low-grade ad-hoc protocol by industry experts. Only local wireless "cloud" traffic is handled by the IEEE 802.11 technology. Each node in the network transmits and receives data, but it does not route any data among the systems connected to it. However, MANETs can be created by fusing various IEEE ad hoc networks together with higher-level protocols.

The design of ad hoc networks is more difficult due to the topology because communication terminals are typically mobile. Each radio terminal can be divided into three categories: power consumed for internal data processing, power consumed for information transmission to the destination, and power consumed when the RT serves as a router by transmitting data to another RT in the network. An important consideration in the architecture of ad hoc networks is energy usage.

Typically, mobile devices have little storage and poor processing power. They rely significantly on other hosts and resources to process information and access data. For Ad Hoc networks, a dependable network architecture must be guaranteed by effective and secure routing protocols. Numerous applications where this kind of characteristic may be advantageous are simple to envision. Communication between vehicles is one interesting topic of inquiry. In this area, ad hoc networks have the potential to transform how we communicate, addressing both our demands for personal and business mobile communication. Additionally, because of the high level of complexity, no conventional (i.e., wired) solution would be appropriate in this area.

Mobility When it comes to challenging environments, such as mines, neither the base station technique nor an ad hoc network can be used; instead, we must be able to carry out routing via network nodes.

The military can employ such networks to implement the next wave of battlefield applications, such as remotely deployed unmanned microsensor networks and situation awareness systems for moving war fighters. Ad hoc networks can be used for communication in non-military circumstances including disaster recovery and message exchanges between security and medical staff taking part in rescue operations.

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1.1WIRELESS SENSOR NETWORK

A wireless detector network is made up of a number of technical transducers with a dispatches system for shadowing and recording conditions at multiple places. Among the variables that are regularly covered are temperature, moisture, pressure, wind direction and speed, light and vibration intensities, sound and vibration levels, power-line voltage, chemical attention, pollution conditions, and important natural processes. The recent networks-directional design makes it possible to manage detector exertion as well. The military's use of wireless detector networks for battleground surveillance and other military activities was a major influence. These networks are used in a variety of consumer and business operations moments, similar to process control, machine health monitoring, and artificial process monitoring.

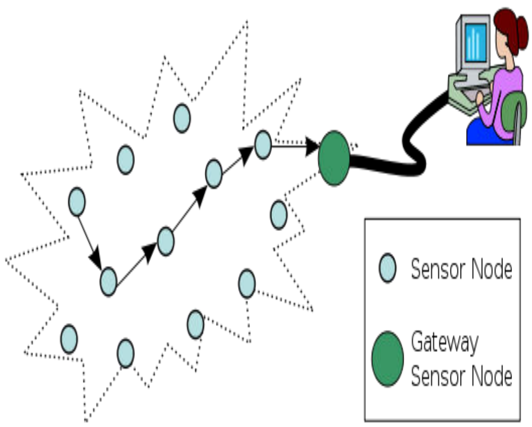

Fig 1: Typical multi-hop wireless sensor network architecture

Each of the "nodes" that make up the WSN is connected to one or more sensors, and their numbers can range from a few to thousands. Sensor nodes, which might cost a few dollars to hundreds of dollars, can vary in complexity from simple to complicated, matching their price range. Resource limitations on sensor nodes, such as those related to size and cost, have an impact on how much energy, memory, calculation speed, and communications bandwidth are available.

Two potential methods for network hop propagation are flooding and routing. Sensor nodes resemble small computers in terms of their components and interfaces. The majority of the time, they are made up of a CPU unit with limited memory and processing capability, a sensor MEMS (with special conditioning circuitry), a radio transceiver or optical communication device, and a power source, which is commonly a battery. Additional features that could be made include energy-harvesting parts, more ASICs, and maybe more communication ports (such RS-232 or USB).

II. RELATED WORK

This paper [1] proposes a new distributed Reinforcement Learning (RL)-based routing solution for WSNs. The suggested method optimizes the lifetime and energy usage of WSNs. Over time, this routing system figures out the best route to the sink node or nodes. Our technique delays the node's death and isolation while guaranteeing improved energy efficiency through dynamic path selection. We take into account node distance, energy availability, and hop count to the sink node while routing messages.

Reinforcement learning (RL), a type of machine learning, allows a system to efficiently pick its future behaviours by learning from its past interactions with its environment [2]. Games, robotics and control, networks, and telecommunications are just a few of the application areas where RL has been applied to create autonomous systems that get better over time. It is well recognised that RL can address optimisation issues with distributed systems in general and network routing in particular.

More than 60 protocols have been released since the middle of the 1990s, each of which has added something new, whether big or small, to the discussion of the best route to take for packet delivery in vibrant communication networks with diverse stoner QoS requirements. This essay offers a thorough analysis of the literature on the subject. The review's layout demonstrates how network conditions and characteristics were decreasingly taken into account over

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More than 60 protocols have been released since the middle of the 1990s, each of which has added something new, whether big or small, to the discussion of the best path to take for sending packets over diverse communication networks with different user QoS requirements. This essay offers a thorough analysis of the literature on the subject. The review's layout demonstrates how network requirements and characteristics were increasingly taken into account over time. To illustrate and compare existing RL-based routing protocols on a qualitative level, classification criteria are proposed. Since the use of a single routing metric by RPL does not meet the requirements for overall routing performance, other routing metrics are mixed thus far. The cluster-based routing protocol (QLCLUSTER) presented in this research uses a novel Q-learning approach to identify [4] the most efficient paths between specific nodes and distant medical stations. A system of mobile biomedical wireless sensor nodes working on a 1000 × 1000 metre flat surface for a simulation time of 600 seconds is used. The results show that the QL-CLUSTER-based approach is faster than other methods at routing packets from the source node to the remote station.

III. PROPOSED WORK

The proposed system suggests that reinforcement learning is a relatively different paradigm in machine learning that can instruct an agent on how to behave in the real world.Consequently, this approach makes it possible to quickly find the shortest paths for a network system or storage structure that is supplied. In computer networks, it is a provided reinforcement learning method for packet routing. To enhance the overall efficiency of the network in terms of average time to delivery of packets under heavy traffic loads, Q learning is used to adaptive network routing algorithms.

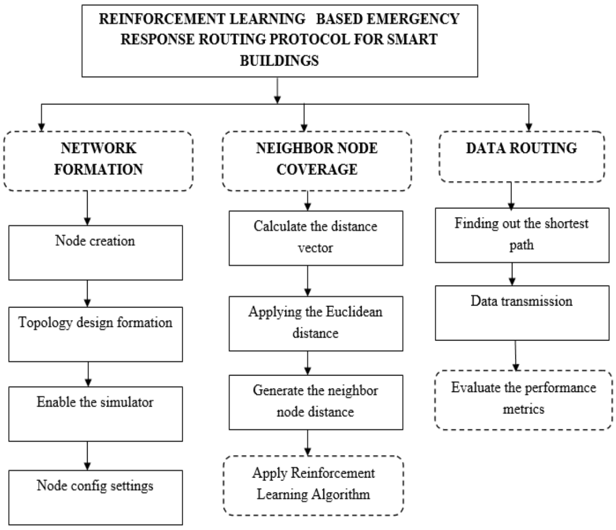

Fig 2: System Architecture

In this module, we can build a topology that gives wireless ad hoc networks access to communication channels. Here, the node will provide information about itself, including the Node ID used for transmission, as well as information about its neighbours. Every node has a routing table that it uses to update its local data. There are nodes that wireless networks produce. The packets must travel from the source to the destination and back again. For ACK packet drop, it is depending on the nodes' packet delivery. In this network, it establishes the source and destination nodes and sends the data to be processed over the entirety of their networking.

Numerous fields require routing, including distributed computing, network routing, vehicular routing, and more. Internet service providers, cloud service providers, distributed blockchain networks, etc. all need network routing. Distance, latency, and cost are some of the factors that are crucial in determining the best path routing.

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IV. RPL ALGORITHM

Without prior knowledge of the network structure or traffic patterns, RL techniques enable the agent to learn via experience. They can modify their routing strategies over time in response to environmental changes. Complex routing issues including congestion control, multi-path routing, and dynamic traffic engineering can be successfully resolved with RL. For a variety of networks, including wired networks, wireless networks, and software-defined networks, Routing techniques based on RL have been researched. They have a number of advantages over conventional routing methods, including greater performance, scalability, and adaptability.

RPL Algorithm

```
Initialize: n_k, ∝_(t+1)=U_(a(r,f)), added_num=0
1. procedure Belief_Update (∝_t,u_r,y_r)
2: while added_num<n_kdo
3:        (s,φ)~ ∝_t
4:        (s,φ,y,-)~G(s,φ,u_r)
5:        if y^(Z(s))=y_r^(Z(s)) then
6:        ∝_(t+1)←∝_(t+1) U{s^',φ^'}
7:        added_num←added_num+1
```

V. RESULTS&DISCUSSION

Accuracy, recall, imply absolute precision, homogeneity index, and f1 rating have been the taka look at criteria. The dedication of those overall performance signs is executed through the usage of actual positives, fake positives, and fake negatives. Accuracy may be described because of the ratio of accurate wonderful magnificence predictions to the entire quantity of accurate wonderful magnificence predictions.

Accuracy = TP / (TP+FP)

The quantity of accurate predictions of the magnificence made on the entire quantity predictions is referred to as the number of recalls.

Precision = TP / (TP+FN)

The F1 rating is a weighted common rating that takes into consideration each accuracy and recall.

Score F1 = 2 * (accuracy * recall) / (accuracy + recall)

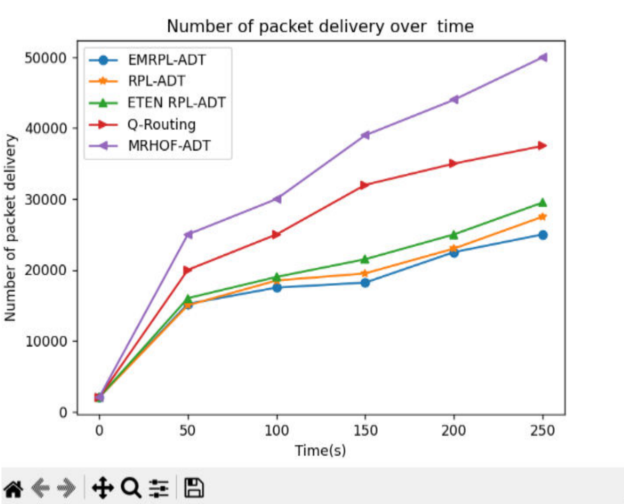

Fig.3. Packet delivery over time

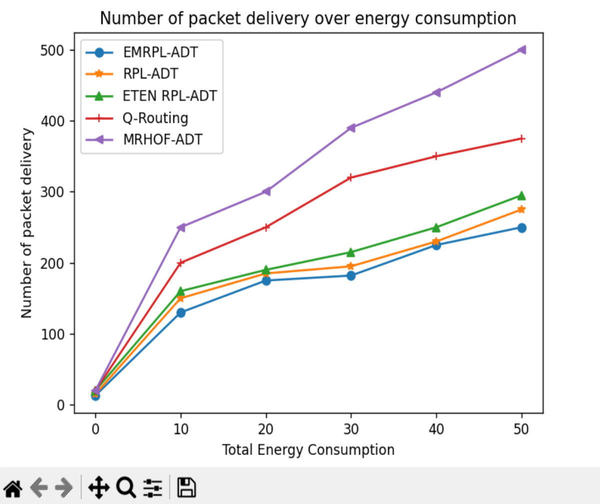

Fig. 4.Total energy consumption

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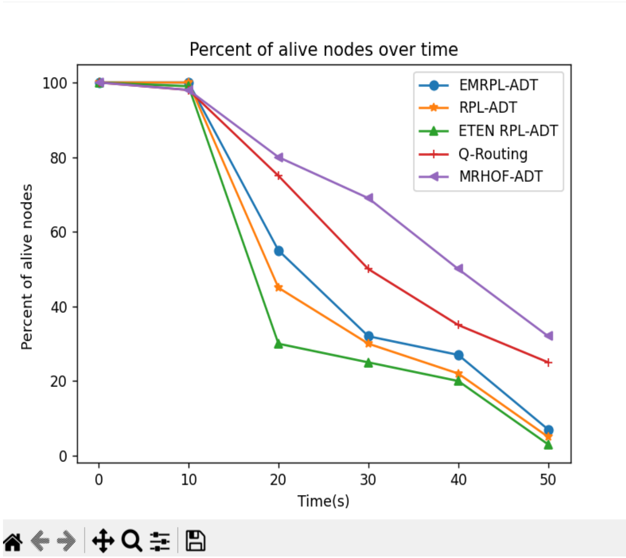

Fig.5. Alive nodes over time

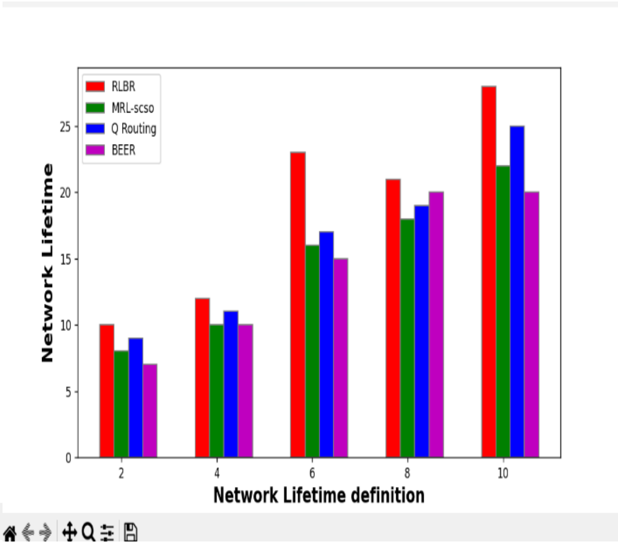

Fig .6. Network lifetime using Reinforcement learning

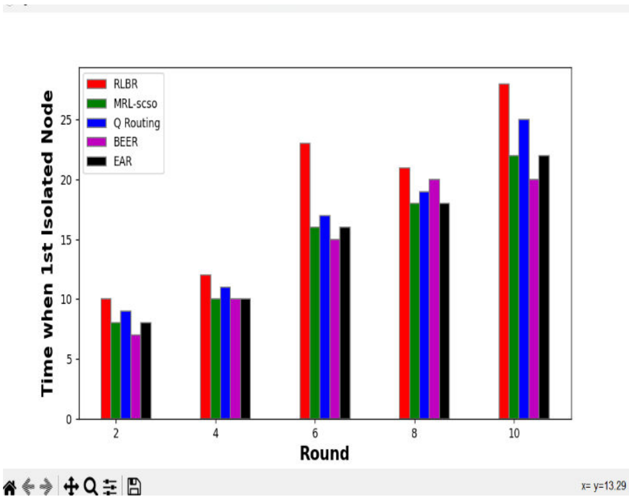

Fig.7. Isolated node using reinforcement learning

VI. CONCLUSION AND FUTURE WORK

The proactive routing protocol RPL constructs acyclic graphs between the nodes to aid in data transfer. The employed algorithm, a modified form of reinforcement learning's Q-learning, adaptively chooses the optimum path for a specific network architecture. This method would find not only a single optimal path but also all conceivable optimum paths for a given network design.The fact that the reinforcement learning approach is model-free and can adaptively find optimal paths in a dynamic and wider network is one of the main reasons to use it for optimal path routing rather than utilizing conventional shortest path algorithms. It is simple to adapt this technique to any network topology, whether they are cyclic or acyclic. This method will have numerous applications in areas like distributed computing, open blockchain, cloud service providers, and more. When deep learning networks are incorporated, this approach can be expanded to very vast state spaces.

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