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# An Efficient Packet Delivery Scheme Using Trust Routing in G.9959 Protocol in a Wireless Sensor Network

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**Abstract:** Wireless Sensor Network (WSN) has drawn high attention in the recent years both in the industrial and the research frontier. It integrates multiple application-based services in areas like disaster management, military usage, smart city, habitat monitoring, healthcare etc. It uses the term Internet of Things (IoT) when providing different services and applications. Similarly, when this network associates with industrial revolution, it is commonly addressed as the Industrial Internet of Things (IIoT). Using IPv6, it gives high scalability using the strength of Internet users. Hence it is crucial to ensure efficiency of the protocols and working modules. This will determine the battery lifetime when it is deployed, connected to the battery's draining short-term. Based on this consideration, many protocols are tested using IIoT in WSN. For this paper we have chosen G.9959 as the protocol and a comparison is drawn with the IPv6 packet delivery rate. Experimental results indicate that the proposed work performs more efficiently when compared to other previous schemes.

**Keywords:** Internet of Things, G.9959, Wireless Sensor Network, IPv6, energy efficiency

## 1. Introduction

The Wireless Sensor Networks (WSNs) are technologically advanced intelligent framework that are used to communicate with other devices using the common internet as a medium of passage [1]. They make use of sensor nodes to monitor various measurement criteria like sound, vibration, pressure, temperature, humidity etc. All these sensors when connect with each other form a smart environment, giving rise to smart transportation, surveillance, healthcare etc. As the advancement of Internet of Things evolved, minute wireless sensing devices have become a common usage in a wide range of intelligent system that find application in industries which have also been evolving at a fast pace in terms of management and services [2]. This revolution in the industries has resulted in the building of automatic working mode using learning and mining. To provide a form of connectivity with other devices, internet is being used as a passage and this aspect is known as industrial IoT (IIoT) [3]. A crucial component of this IIoT is WSNs which is used to exchange knowledge between the various intelligent objects. This process can be achieved using the IPv6 in a typical 6 Low Power Wireless Personal Area Network 6LoWPAN using the IEEE 802 standard [4] in which it is designed to run. In this paper we have proposed to make use of the G.9959 protocol to deliver the IPv6 packets. The proposed protocol uses 3 channels [5] that are placed with a rate of 100 kbits/s, 40 kbits/s and 9.6 kbits/s. Moreover, it also gives reassembly and segmentation of the payloads of 1350 octets. This protocol will behave as the intermediate between WSN and the IP network. In general a typical IPv6 packet will hold 1280 bytes which can also be accommodated into one G.9959 frame [6]. When this packet is sent through 6LoWPAN, it will be broken into many small packets and every small packet will be able to be



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accommodated inside a single MAC (Media Access Control) frame. However, about 130 octets of G.9959 MAC Payload Data Unit are available to hold this information and hence data from 6LoWPAN are sent to the octets using an encapsulation header stack [7]. The stacks will hold a header type which is usually preceded by header fields or a zero. A typical header stack of IPv6 will comprise of the following information: payload, destination options, fragmentation, routing, hop-by-hop options and addressing [8]. In the proposed work we have made use of oG.9959 which holds high data rate and 3 channels to choose from [9]. We have incorporated a new channel allocation scheme with the proposed protocol in the MAC layer while fragmentation overhead is used to analyse the obtained result. In order to attain high efficiency, a packet delivery system is also used which will enhance the network coding features [10-11].

## 2. Problem Formulation and Contribution

A WSN will enable and keep track of multiple smart devices in an IIoT. An industry employer or the end user will be in control of these devices and make use of commands which are encapsulated in IPv6 packets. When these packets are received at the node, fragmentation of the packets [12] is commenced and these fragments are further sent to the next hop node till it is received at the destination node [13]. When forwarding, the sensor nodes will not able to send their sensed data along with these fragments, resulting in wastage of resources and delay in the time frame, reflecting in decreasing the energy efficiency of the system. Since 6loWPAN will have more number of fragments when compared with G.9959, it will result in increasing the total number of transmissions. This will lead to the exhaustion of energy available. On the other hand, the sensor nodes are also refrained from sending the data that they sense which will result in a notable delay.

In order to overcome these difficulties, we have proposed a more energy efficient packet delivery scheme that is designed for IIoT purpose. Our inputs can be summarised as given below:

- Using network coding, we propose a novel packet delivery scheme over WSN
- Using G.9959, a novel channel allocation scheme is established and .the use of MAC layer is discarded. Thus the bandwidth of othe channels are used as per the data rate and size required.
- A relationship between utilized bandwidth and energy is established.

## 3. Proposed Work

### 3.1 Channel Allocation

G.9959 is the new standard wireless protocol that has been developed by international telecommunication union (ITU) which has the bandwidth of 1GHz. The G.9959 protocol is found to be provide Quality of Service (QoS) for bandwidth allocation and channel utilization, adding reliability to the system. Energy consumption is directly dependent on the bandwidth and will affect its performance metric. In the protocols used prior to G.9959, i.e. IEEE 802, bandwidth was allocated in only one channel and its metrics followed standard MAC requisitions. Hence, when data rate is high for the channel, it will result in improper resource utilization to transfer packets or fragments that are of small sizes. Because of this reason, overhead was found to be high and bandwidth was also wasted. To overcome these discrepancies, we have proposed the use of G.9959 in the place of IEEE 802 standard. This protocol is built to support 3 bandwidth channels that are known as R1, R2 and R3 representing their bandwith rate of 9.6 kbits/s, 40 kbits/s and 100 kbits/s respectively. Here R3 bandwidth is used to transmit IPv6 packets or fragments while the other two bandwidths are used for forwarding the sensor nodes' data. Transmission



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of packets in a parallel manner is also supported by G.9959 leading to better computing performance when transmitting multiple data packets simultaneously. Thus this protocol will decrease energy consumption by reducing delay in transmission of data. An additional feature of G.9959 is the MAC frame size that is supports (130 bytes), which is found to have a lower congestion and overhead when compared with the IPv6 packets' capacity in IEEE 802 standard.

### 3.2 Packet Delivery Scheme

In the gateway node of a typical IP network, the IPv6 packets are first fragmented as per MAC requisition in order to fit the MAC layer. Every packet inside the fragments are divided into smaller fragments in order to see that they best fit the MAC frame. In general the IPv6 packet can be divided into downward and upward packet. Here the downward packets represent the packets that are received by the node from external IP networks while the upward packets represent packets that are sent from the sensor nodes to establish communication with the external networks. The upwards packets do not require fragmentation since the packet size is small and will be able to fit into one IP packet. But, the packets that are received by the node from other IP networks will require fragmentation. Let $N_g$ represent gateway nodes and the other nodes of the WSN are given by $N_1$, $N_2$, $N_3$...$N_n$. The packets are transmitted using a trust-based routing protocol such that

$$T_f(P_i) \propto No.of\ packets\ transmitted$$

where $P_i$ is the path and $T_f(P_i)$ is the trust factor for the path. Thus it can be calculated as follows:

$$T_f(P_i) = \frac{P_{avg}}{D_{avg}}$$

where $D_{avg}$ and $P_{avg}$ can be computed using the formula:

$$P_{avg} = \frac{No.of\ successful\ packets\ transmitted}{Total\ packets\ tranmitted}$$

$$D_{avg} = \frac{Delay\ over\ the\ path}{\sum_{j=0}^{n} Delay\ over\ the\ path}$$

On fragmenting the IPv6 packets, either intermediate node forwarding strategy or gateway node forwarding strategy can be followed based on the required. Node $N_g$ will follow the gateway node forwarding strategy while the other nodes will follow the former strategy. The node $N_i$ will fix the MAC frame size such that:

$$l_i = \max_{x \in 1,2} x \leq \frac{1}{b_{i,i+1}} - H_p, H_m + 80 \leq x \leq 1040$$



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where $H_p$ and $H_m$ represent the PHY header size and G.9959 MAC frame header size while $b_{i,i+1}$ is the Bit Error Rate of the link. $l_i$ represents the size of the frame. After the downward packet is received by $N_g$, the following steps are executed in this proposed work:

- **Step 1:** The size of the received packet is compared with the size of IPv6 packet. If it exceeds, step 3 will be executed else the value of $s_0$ will be set as 1.
- **Step 2:** When the IPv6 packet size is more, $N_0$ will fragments the received packet into chucks of $s_0$.
- **Step 3:** The fragmented chunks are then encoded with network coding scheme.
- **Step 4:** With the help of channel capacity, the data rate $D_0$ is determined to transmit the packet. Based on the value, the right channel is chosen to transmit the fragmented frames.
- **Step 5:** The intermediate node will forward the frame to the next path or node till the packet reaches the destination.

We propose the use of trust factor based routing to choose the right path to route the packet towards its destination. The other WSN nodes will behave like relay during this process. Thus the packet is delivered in an efficient manner with multicast support.

### 3.3. Energy Consumption and Bandwidth

To ensure equality among the transmitting rates of the different packet sizes, there should be a constraint in bandwidth consumption. Hence there must an intelligent system to allocate the bandwidth of the packets in channel allocation with respect to the data packets' size and transmission rates. If y(t) is the signal, then the energy E is expressed as:

$$E_y = \int_{\infty}^{-\infty} y(t)^2 dt$$

On further elaboration, it can also be expressed in correlation as:

$$E_x = \frac{1}{2\pi} \int_{-\infty}^{\infty} Y(B)Y(-B)dB$$

For real time y(t), it is observed that Y(-B) and Y(B) are found to be conjugates of each other. Similarly to calculate the bandwidth efficiency $B_\eta$ such that

$$B_\eta = R(I_1\left(R, \frac{E_{t\propto al}}{(D_e)^\eta}\right))^k$$

where R is the code and $(I_1\left(R, \frac{E_{t\propto al}}{(D_e)^\eta}\right))$ represents the probability of successful reception of the packets in single hop. Fig.1 represents a random IoT oriented WSN with over 500 nodes in activation.



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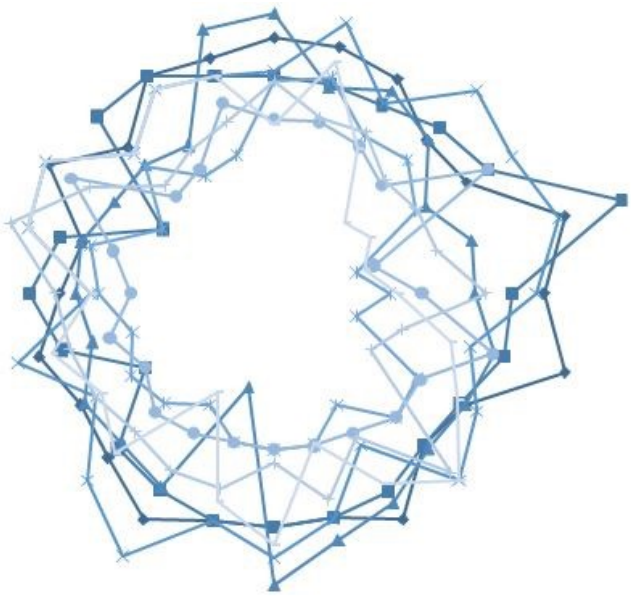

**Fig. 1. A random IoT oriented WSN with more than 500 nodes**

## 4. Simulation Results

The network's lifetime is connected to the energy saved for further processing. Hence if there is an increment in the lifetime of the network, it will result in improving the performance of the sensor network. But the terms network lifetime, energy and sensor nodes are correlated to each other. Hence in order to obtain better performance, we have proposed a methodology which will be able to allocate fair energy and bandwidth. Fig.2 shows the performance of the sensor notes in terms of network lifetime for different approaches and it is found that the proposed strategy attains a lifetime which is higher than the other approaches examined.



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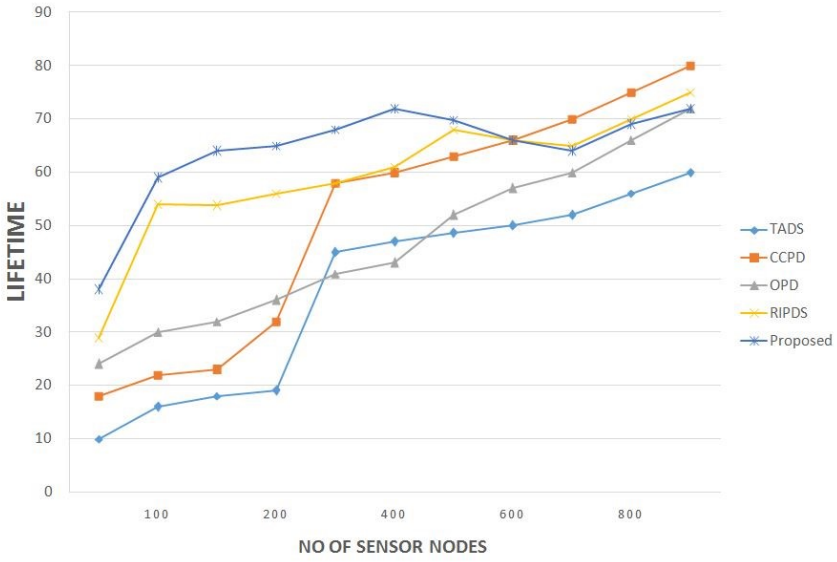


**Fig.2 Performance in terms of network lifetime**

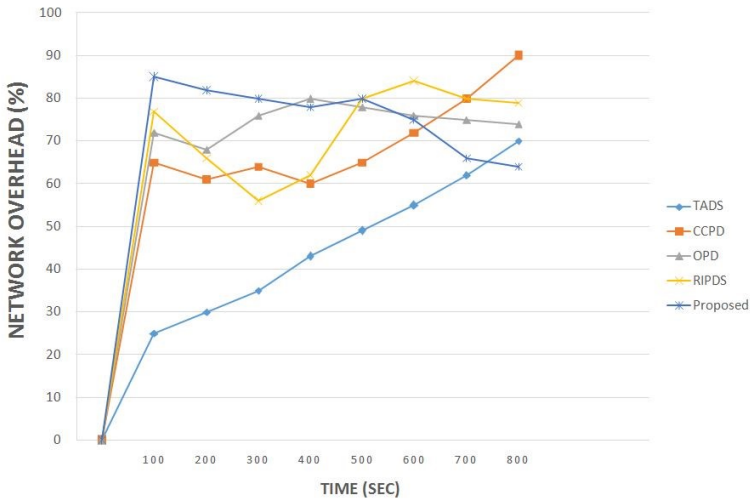


**Fig.3. Performance in terms of network overhead**

Like lifetime, overhead will also have an impact on the performance of the system for further processing. If the network's overhead is high, it will decrease the sensor network's performance. In order to improve the performance, our proposed methodology will be able to decrease fragmentation process and sustain allocation of bandwidth. In Fig.3 it can be observed that there is less overhead in the proposed methodology when compared with the other approaches.



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## 5. Conclusion

As advancement in IoT and WSN progresses at a rapid pace, it has paved way to effective communication means in everyday life style, using smart devices. These devices maintain transparency with other users while staying interconnected to the internet for remote access. When a wireless medium is used as the channel for communication, the packet drop rate is also high. Moreover, means for transmitting sensed information is also lacking in the packet delivery scheme. To address these shortcomings, we have proposed the use of G.9959 protocol to deliver the packets. It provides a safer way to transmit the sensed data by performing encoding and decoding based on the channel/path that is chosen. The performance of the proposed system is measured in terms of energy, packet delivery ratio, overhead and lifetime. Results indicate that this proposed methodology outperforms the other methodologies that are used. As a part of future study, we can build an app that will put this system in practise, real-time.

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