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Scheduling in LoRa Gateways to Reduce Packet Loss

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Abstract

As the Internet of Things grows, LoRa (Long Range) technology is crucial. However, SX1280 networks' end-nodes and gateways' interactions have been neglected in previous study. This chapter handles packet loss by limiting the number of LoRa nodes connected to a gateway. This article also discusses IoT communication network scheduling tactics to improve efficiency. This artifact-based model shows range influences packet loss in gateway-connected SX1280 end-nodes and how to enhance scheduling. The normal LoRa setup delivers 0.6% of packets, however this research advises utilizing an autonomous collision-free scheduling technique to maximize system performance. Internet of Things LoRa SX1280 nodes and gateways may help research.

Index Terms— Internet of Things, LoRa, SX1280, Semtech, Scheduling, LoRa Communication, Packets, Gateways, SX1280, Network Scheduling.

I. INTRODUCTION

Because of the meteoric rise in the number of Internet of Things–enabled smart devices, additional research into the technology of low–power wide–area networks (LP–WAN) is required. It is anticipated that by the year 2025, more than 21 billion Internet of Things devices will be connected to the internet. Technologies of communication that consume little power and last a long time are absolutely necessary for the proper and dependable operation of modern electronics. This is due to the fact that there is a cap on the capabilities of an Internet of Things device. As a potential solution to this problem, LoRa should be considered. LoRa is an innovative technology that enables connectivity over LP-WANs and is exhibiting a great deal of promise in this regard. As a method of physical layer modulation, it makes use of the spectrum at 2.4 GHz, which is not licensed for use [1].

These low-power Internet of Things devices can successfully communicate with one another using the LoRa 2.4 GHz wireless sensor network, according to the findings of some studies that were conducted not too long ago. The LoRa SX1280 chipset was developed by Semtech, and it has the ability to communicate on a worldwide 2.4GHz frequency band, have a high range (it can travel kilometres), operate with a low amount of power (it can run for months on a single charge), and have a long range. It can do all of these things simultaneously. Despite this, there are ongoing investigations, both theoretical and practical, into the dependability of the range and the various ways in which its performance can be improved. Our company believes that additional research into the connectivity between SX1280 terminals and gateways is required. While the SX1280 nodes are written in C and make use of Semtech libraries, the gateway is an integrated platform based on a Raspberry Pi computer that runs the Linux operating system [2].

Through research and analysis of previous cases, we were able to determine how far LoRa devices can transmit and when it is appropriate to use them. To the best of our knowledge, the Semtech SX1280 2.4Ghz LoRa kit is not very dependable. Because there is a lack of information regarding the actual operation of the SX1280 LoRa kit in the real world, it is difficult to learn more about LoRa despite the fact that it is used in a significant number of the company's products [3].

This research aims to close the knowledge gap and improve the efficiency of layered architectures that are governed by SDNs by conducting an extensive investigation of a range LoRa node that is also equipped with a gateway and scheduling algorithms. Accurate range estimation is essential because there are many useful applications that require working and communicating from remote locations. The detection of forest fires in Australia is a prime example of this. Installing smoke detectors will allow you to detect a fire in the forest from a great distance. It is necessary to determine how far it can be relocated in order to avoid significant communication loss. This can be done by determining how far it is possible to move it. Because ALOHA transmission is used, the possibility of a collision between LoRa packets rises when there are a small number of nodes in the network. This highlights the necessity of identifying the most appropriate scheduling method for use with LoRa devices in order to maximize communication efficiency, minimize packet loss, and seamlessly incorporate the context of the IoT system [4]. The findings of the research indicate that in open areas, LOS and NLOS provide the operating ranges with the lowest packet loss (NLOS). Increasing the Packet Delivery Ratio is another way that using the best-fit scheduling strategy can help you become more efficient (PDR). The results of this study will also shed light on the versatility of the Semtech SX1280 kit across a wide range of different settings and parameters [5].

II. RELATED WORK

In this study, we look at articles that are related to one another. The most significant challenges are first covered, followed by an in-depth examination of the scheduling issues. Let's have a look at what they go by in public:

This article discusses many significant research on the LoRA 2.4GHz range. It could be challenging to zero down on the optimal solution in a broad array of settings. It is possible to determine possible sites for the implementation of this technology as well as projected verification timeframes. The communication range that is accessible is an important factor that determines how well data can be sent across large distances, such as when sending sensor data. This factor is critical for a broad variety of applications [6].

Using Semtech's LoRa technology, manufacturers may now construct chipsets with a range of kilometres. This is possible since the technology operates in the widely accessible 2.4 frequency band as well as the available sub-GHz. The LoRa module SX1280 delivers significantly extended communication range, despite the fact that there is considerable interference on a frequency that is regularly utilised. We present a rigorous mathematical description of the LoRa physical layer that operates in the 2.4 GHz range as part of this investigation. The communication capabilities of this technology have also been evaluated under three distinct test scenarios to determine their maximum reach [7]. The modulated 2.4 GHz LoRa signal has been simulated in a variety of contexts, including indoor, urban path loss, and free space situations, each with a unique bandwidth and spreading factor. Research has also been done on the best data transfer speeds. According to the data, the greatest range that can be achieved inside of a building is 107 metres, while the highest range that can be achieved outside in the open is 333 kilometres, and the maximum range that can be achieved inside an urban environment is 867 kilometres [8]. The highest feasible data rate is 253.91 kbit/s, with a maximum range data rate of 0.595 kbit/s being attainable under any and all circumstances. When compared to other technologies operating in the 2.4 GHz band, LoRa's superior performance in terms of communication range may be attributed to the low data rates it uses and the fact that its bandwidth can be adjusted. Private LoRa networks provide greater localization accuracy and bandwidth when compared to public sub-GHz networks. This advantage is beneficial to both the process of localization and the applications that are deployed on private LoRa networks [9].

LoRaWAN has been emphasized in the implementation of numerous Internet of Things applications regarding Scheduling due to its capabilities of long-distance communication, highly low-cost consumption, and low-power wireless communication. This is because LoRaWAN is able to communicate over longer distances at a lower cost. Recent research has indicated that the ALOHA-like quality of the MAC layer of the Lo-RaWAN protocol places a constraint on the scalability of the Lo-RaWAN protocol for use with class A devices. Haxhibeqiri et al. lays out the LoRaWAN network's scheduling method and demonstrates how class A devices may be synchronized with one another. The method works on a layer that is higher than the MAC that LoRaWAN uses. The time of transmissions in both the downlink and the uplink directions will be synchronized thanks to the coordination provided by the scheduling entity and the central network synchronization [10].

A data format that is economical with space is used to represent the time slots of the end node. When determining when to broadcast, the last node will take into consideration the format of the data that is coming in, which may include the presence or absence of a certain time frame. The distribution of time slots is decided based on how much foot traffic is required at the terminals. The Packet Delivery Ratio (PDR) of a non-saturated multichannel LoRaWAN network with independent channel synchronization ranges from 7% for SF7 to 30% for SF12 when compared to an unsynchronized LoRaWAN network. This range is determined by the number of channels in the network. The PDR gap is an excellent solution for a busy network because it enables nodes to be scheduled before they can be accommodated in the network. Less than 3 mAh of extra battery capacity is required per node on an annual basis for synchronization, which is less than the battery capacity that is necessary to transmit packets that are lost because of collisions in a network that is not synced [11]. Finally, we established that local applications would benefit from a direct line of sight, especially when attempting to maximize throughput within a tight bandwidth. This was accomplished by demonstrating that local applications would benefit from a direct line of sight. Therefore, LoRaWAN is developing a system that assigns time slots according to the requirements of the traffic; PDR is an essential component in the process of improving LoRa communication [12].

Fig. 1. A view of Semtech SX1280 development kit

III. METHODOLOGY

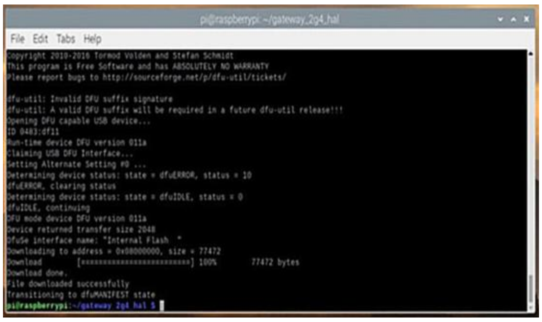
The purpose of this investigation was to ascertain the effect that packet loss has on the transmission distance of the LoRa communication platform. It's possible that we'll also look at methods to develop scheduling algorithms that, in the event that packets are dropped, make communication more effective. During our inquiry, we used an approach that was artifact-based. The research, which makes use of contemporary methods and technologies, is expected to provide some intriguing discoveries for the benefit of readers and scholars. As shown in Figure 1, we not only used Semtech SX1280 development kits for our project, but we also used others. In this section, we will discuss in more depth the procedures that were followed in the tests. To provide more clarity, an SX1280RF1ZHP is a single instance of an SX1280 2.4GHz RF module. A development platform for the STM32 Nucleo-64 family, this NUCLEO-L073RZ board has the STM32L073RZ microcontroller as well as a USB connector. goals that provide room for adjustment [14].

According to the National Science Foundation (NSF), research into cloud computing is only getting started despite extensive usage by organisations and industries. There are still many holes in the cloud architecture that have not been closed, and new dangers are appearing all the time. An overview of the most important issues that still need for more research may be found in the sections that follow below [15]. Security of the hypervisor: If the security of the hypervisor is breached, cloud computing will have a lower level of overall security. There is a possibility that the integrity of the network as a whole has been severely damaged. Because of the cloud's inherent fluidity, the tried-and-true procedures for locating the source of a problem and resolving it are no longer applicable. These technologies are very necessary in order to differentiate between regular and aberrant actions carried out in the cloud. As a consequence of this, it is critical to put into action any recommended adjustments as promptly as possible in order to avoid causing any interruptions to the cloud's underlying infrastructure or to regular business operations. Auditors who are trained professionals and who maintain objectivity Worries concerning the loss of data and deletion of data as a result of hardware-software failures and/or human error have gained popularity alongside more general concerns about the safety of cloud-based data storage systems. It is recommended that the integrity check be carried out by an experienced auditor from outside the organization. During the course of an audit, a client's sensitive information should not be made available to a third-party auditor working for a public cloud service. As a consequence of this, there is a new substantial worry about the protection of personal information, and that is the chance that external auditors may gain access to sensitive information. Cloud security is a pressing concern for industry professionals, who are always on the lookout for novel solutions to the problem.

After a security flaw was discovered, the system has to be brought back to its usual functioning state. The amount of data, software, and hardware that authorized users are permitted to request and get access to in response to those requests. We say that a system is available when the tasks that run on it can be finished whenever they are required to be done. Data protection, availability, and security have proven to be three of the most challenging challenges presented by cloud computing.

The process of wiping data, reorganizing data, or transferring data to a new user is referred to as "data remanence." The confidentiality of information that has been deleted in the past is jeopardised as a result of this. Computer forensics and perhaps even some other methods might be used in order to figure out what happened to the information and find out how it was lost. Another frequent instance in which data recovery software is useful is when data has been deleted by accident. Despite the fact that the problem of data retention is a serious concern, cloud firms have not made a significant amount of progress in addressing it.

It was said in a way that was not correct that the proposed security processes for IaaS would ensure the network's safety. Even the most advanced firewalls can only stop some types of attacks. Because of the DNS disruption, a large number of attacks were uncovered, which raised more questions about the safety of cloud computing. Because there has not been enough research done on the issue of reusing IP addresses, there have been data and system breaches that have compromised the users' privacy and security. IaaS is hosted in the cloud, which means that conventional access control and identity management solutions cannot be used to bolster its defenses. Computer security in the modern day requires the use of cutting-edge technologies such as blockchain and artificial intelligence. The majority of authentication strategies have a cumbersome implementation process and call for a large investment of time and effort. When researchers in the past had limited access to data, resources, and a sample size of customers, they resorted to simulation as an alternative to more traditional ways of evaluating their theories. This allowed them to test their ideas without being hindered by their lack of resources. At first glance, the cloud may seem to be a straightforward concept; nevertheless, it is really a complicated system that consists of numerous moving parts and a large number of users. Additional study on the many possible answers to these problems is required as soon as possible. Regrettably, the supplier of cloud services does not provide a platform that enables simultaneous access via several user interfaces.



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This program is Free Software and has ABSOLUTELY NO WARRANTY
Please report bugs to http://sourceforge.net/p/dfu-util/tickets/

dfu-util: Invalid DFU suffix signature
dfu-util: A valid DFU suffix will be required in a future dfu-util release!!!
Opening DFU capable USB device...
ID 0483:df11
Run-time device DFU version 011a
Claiming USB DFU Interface...
Setting Alternate Setting #0 ...
Determining device status: state = dfuERROR, status = 10
dfuERROR, clearing status
Determining device status: state = dfuIDLE, status = 0
dfuIDLE, continuing
DFU mode device DFU version 011a
Device returned transfer size 2048
DfuSe interface name: "Internal Flash  "
Downloading to address = 0x08000000, size = 77472
Download        [=========================] 100%        77472 bytes
Download done.
File downloaded successfully
Transitioning to dfuMANIFEST state
pi@raspberrypi:~/gateway_2g4_hal $ 
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Fig. 2. User Interface

However, there was also something available that was known as an SX1280 Gateway Development kit. This kit had the following components: • a solitary SX1280 gateway module. A lone 2.4 GHz antenna: A Raspberry-pi (RPI) 4 mini-PC and one SX1280 gateway interface board are required. The Raspberry Pi can be connected to a 9-pin male DC power supply through a single USB wire. Since STMCubeIDE can build communication code on the fly based on client requirements and already has pre-loaded libraries for a variety of boards, it was chosen as the programming environment for the End-Device kit. Simply said, the NUCLEO-L073RZ board that we were working with was chosen so that the internal architecture and some instances of its use could be shown. Alternately, the HAL library that is provided by Semtech is loaded into the Linus OS that is used to power the SX1280 gateway that is hosted on a Raspberry Pi. a cable for USB, the gateway module, which is an essential component of the gateway, must maintain a connection to the Micro USB port on the RPI in order to receive instructions and maintain its power supply. After many trials and error, we were ultimately successful in getting this working by directing the micro-USB connection on the Raspberry Pi to utilize the ttyACM0 serial port. After this has been completed, the MCU binary file and the packet forwarder file are the only two files that are need in order to read messages.

IV. RESULTS AND DISCUSSIONS

The experiment conducted between the Brisbane city east riverfront and the Kangaroo point Terrace was successful and gave positive results when the line-of-sight connectivity was available. The end-host sent 119 packets from five positions during the experimental process to calculate the packet loss between the communication. The positions were randomly selected according to the distance, i.e., 650 meters, 850 meters, 1200 meters, 1500 meters, and 1600 meters away from the gateway.

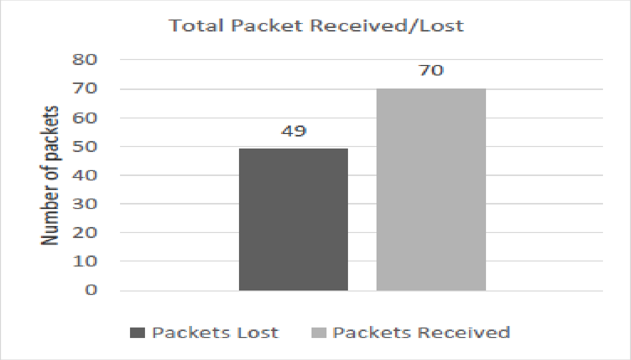

Fig. 3. Total number of packet Received/Lost.

Figure 3 shows that the gateway received 70 of 120 packets, while 49 were lost in transit. The power dissipation ratio was 0.58 because less than 60% of the transmitted energy was wasted. Figure 5 provides further information. This PDR lacks contrast compared to other wireless communication methods. Packet collisions cause lost packets.

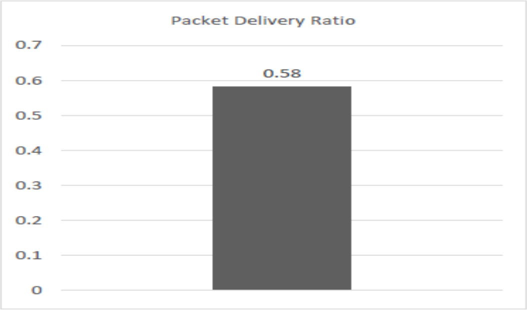

Fig. 4. Packet delivery ratio

Figure 4 demonstrates that there is only a 13% chance of losing packets at 650 metres. At a distance of 850 metres, it was found that there was a 19% loss in packets. At 1200 metres, there was a loss of 33% of the packets, while at 1500 metres, there was a loss of 39%. When we relocated the end device farther away from the gateway, we saw a substantial rise in the percentage of lost packets, which reached 82%.

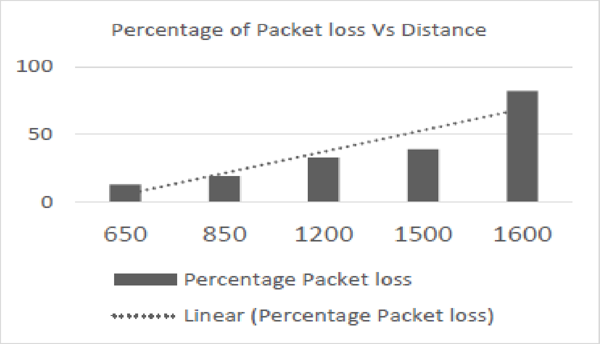

Fig. 5. Percentage of Packet Loss vs Distance

In addition, we analyzed the data to determine the number of packets that were received on each channel at a range of different distances. This is due to the fact that switching channels is a significant factor in the packet loss that occurs as a consequence of collisions. As may be observed in Figure 7, the distribution of incoming packets on Channels 0 through 2.

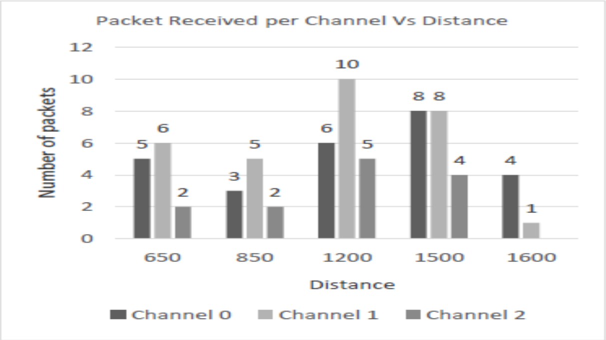

Fig. 6. Packet Received per Channel vs. Distance.

As can be seen in Figure 6, the vast majority of packets, thirty out of a total of seventy, were picked up by Channel 1 at a frequency of 2479 MHz. On the other hand, only 26 of 70 packets were received by channel 0 at a frequency of 2403 MHz. Channel 2, which operated on a frequency of 2425MHz, was only successful in picking up 14 of the 70 broadcasts. If you look at the graph in further detail, you'll see that Channel 1 is by far the most common LoRa communication channel. Channel 0 and Channel 2 come in second and third, respectively. Because of this, the frequency of 2479MHz is the one that the node uses the majority of the time to broadcast its data packets. This points to the possibility that packet loss might be caused by transmission collisions on the same frequency.

Figure 7 provides more evidence that the received signal strength indication is subject to a great deal of variation (RSSI). Alterations are made at both the primary and secondary locations in exactly the same way. It is imperative that you take into consideration the fact that the primary antenna in this experiment only gains +10dB. As a consequence of this, it is possible that this is the reason why the RSSI component variance of the experiment was not fully characterized. According to what we discovered, the RSSI can be anywhere from -100.0 to -100.0. The actual range that was reached was far less than what was anticipated because of the height of the gateway, which was 18 metres, and the end device's direct line of sight. This demonstrates that future research might look into ways to enhance antennas as a topic of investigation.

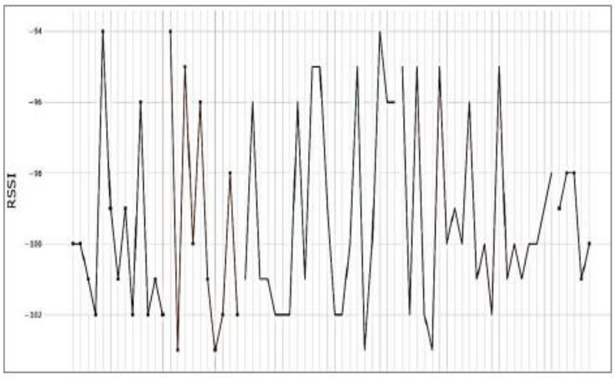

Fig.7. RSSI Vs. Packet Received

The year 2019 saw the introduction of a best-fit scheduling mechanism by Dimitrios Z. and Brendan O. This mechanism provides a time-slotted collision-free scheduling solution without the overhead price of extra communication. The PDR reaps the advantages of this situation whenever new nodes are added to the gateway. During this step of the procedure, the gateway will first transform the IDs of the various nodes into slots, and it will then distribute these slots to the nodes. Because we only measured using a single node and gateway connection for all of our tests, it's feasible that if we utilised more nodes, the percentage of dropped packets would rise while the packet delivery ratio (PDR) would fall.

The MAC address must first be given a slot value before moving on to the next part of this procedure. Each LoRa device has its own one-of-a-kind MAC address, which consists of either 16 characters or 64 bits in length. Requests to join from potential nodes are sent to the gateway together with the spreading factor and a singular identification (SF). The equation is used to express the Spread factor, and the gateway is responsible for computing a set of "A" for each node depending on this value. The MAC address must first be given a slot value before moving on to the next part of this procedure. Each LoRa device has its own one-of-a-kind MAC address, which consists of either 16 characters or 64 bits in length. Requests to join from potential nodes are sent to the gateway together with the spreading factor and a singular identification (SF). The equation is used to express the Spread factor, and the gateway is responsible for computing a set of "A" for each node depending on this value.

CONCLUSION

Researchers found that employing a time-slotted collision-free scheduling strategy raised the LoRa network's packet delivery ratio to over 100% for ten nodes, while utilizing LoRa's default configuration resulted in a ratio of less than 0.6 for the delivery of data packets. The benefit of using this strategy is that it makes use of a node's one-of-a-kind MAC address to calculate the transmission slot that will result in the gateway transmitting the barest minimum of data to the node. This is accomplished by using the MAC address of the gateway. The only limitation of this research is that it may have benefitted from more testing that was carried out utilizing a larger sample size of nodes. If the experiment is redone with a more capable antenna, it is also possible to evaluate the relevance of the gain factor of the antenna in relation to LoRa communication. The outcomes of our study are of a quality that allows them to be used in subsequent research. In the future, one of our goals is to increase the connectivity of our LoRa network while keeping the same high standard of service.

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