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Protocol Design for 6LoWPAN

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ABSTRACT: IPv6 over low power devices is currently being used in many IOT enabled devices. Since the majority of the devices have limited buffer space, effectively utilizing buffer space is the main criteria. Many protocols have been developed for the past few decades which focuses mainly on optimizing the buffer utilization criteria. Even with rapid growth in current technology 6LoWPAN devices are facing a huge problem mainly due to the large header size of the protocols in different layers. Many protocols have been created over the last few years which use IEEE 802.15.4 in the MAC layer which reduces the header size to 33 bytes and also provides fragmentation and reassembly. But again since encapsulation is used, it introduces redundancy in certain fields such as length field, which will be present in all the layers or IP version field, which is always IPV6 when it comes to 6LoWPAN. So in this paper a new protocol is proposed which completely removes such redundancy, and still can be used in the routing protocols used currently.

KEYWORDS: Wireless Sensor Networks, Software Defined Networking, 6LoWPAN, Internet of Things

I. INTRODUCTION

Even though the Internet of Things(IoT) is not known by all, it is still a developing technology which uses low power embedded devices to capture data and transmit over the internet. For the past few decades there has been an incomparable development in both speed and connectivity such that it has reached a point of saturation and in today's world speed and connectivity are no longer a major challenge among developers. The main focus among all developers is to take advantage of the available connectivity and speed so that the resources can be used effectively and efficiently. Majority of the IOT devices are low cost devices thus demanding efficient utilization of resources. Limited buffer space is one of the major concerns for such low power devices connected via internet.

Currently IPv4 is being used in a majority of the devices. But since the number of devices connected to the internet is very much larger than the number of available IP addresses there is a rapid depletion in the available IP addresses. To overcome this problem Network Address Translators(NAT) are being used so that a large number of devices can be formed into logical groups and provide a single IP address to the entire group. But this increases the processing time at every node which converting addresses using NAT, thus all the packets will be queued in the node which increases queue time thus the overall speed of the network is compromised. Thus, there is a need to increase the address space so that more devices can be accommodated without any conversion from public to private IP address. This led to the development of IPv6 has a 128 bit address space and can accommodate 3.4*10^38 devices. Many steps have been initiated to convert the entire network all around the globe to support IPv6.

Since the entire network is being changed to IPv6 format, there is a need for the IoT devices to support IPv6 in the near future. Another problem with IoT devices is that, since the cost of each device is less the amount of available resources is also less. To support such devices with very less resources, IEEE 802.15.4 was developed. IoT based devices usually use IEEE 802.15.4 as the MAC layer protocol. For the network layer IPv6 can be used but due to size constraints of the MAC layer protocol, the network layer protocol will have to be compressed and therefore an adaptation layer is added which will compress the upper layer header to as low as 6 bytes, which is the bestcase scenario. In the transport layer usually UDP protocol is used primarily due to its lack of any congestion control algorithm. Since IoT based devices are usually used to provide sensor data, it is real-time and retransmission will cause false data to be received by the receiver.

The following paper is divided into 5 sections. The first section is about the IEEE 802.15.4 protocol which was developed mainly to support low power noisy networks. The second section is mainly about the adaptation layer which is used in 6LoWPAN devices to compress headers. The third section is about the new frame format which was developed to support low power and noisy networks. The fourth section is about the conclusion of the entire paper which compares the new proposed protocol along with the currently used protocol. And the last section is about the results obtained when the new proposed frame format is used.

II. RELATED WORK

In [1], the security threats in devices utilizing low power devices was discussed along with the methods to mitigate them. The main type of attacks focused in [1], werebuffer reservation attacks. In [2], memory management techniques whichcan be utilized in low power devices were discussed. [2] mainly focused on IPv6 protocol for low power devices.

In [3], security threats were analysed. The paper mainly focused fragmentation attacks on low power devices and ways to overcome the issue was also discussed. In [4], fragmentation methods were discussed along with ways to reassemble the fragmented packets in a memory efficient way. In [5], 6LoWPAN based network was created which could detect congestion in the network and take appropriate steps without consuming huge enormous amount of power. In [6], efficient fragmentation compression schemes were analyzed and a new approach was designed based on the collective information about from the analyzed information. In [7], buffer management strategies were analyzed and tolerate high speed data transmission network.

III. COMMUNICATION PROTOCOL

A. *IEEE 802.15.4:*

IEEE 802.15.4 is a wireless access technology which is currently being used for low cost and low data rate devices. IEEE 802.15.4 is the foundation for several protocol stacks such as 6LoWPAN, Zigbee and so on. The devices which are using this protocol are usually powered using a battery and thus power consumption is of utmost concern. IEEE 802.15.4 is both simple and flexible protocol and it is mainly used for domestic purposes. The maximum MTU of IEEE 802.15.4 is 127 Bytes. Even though there are a few problems such as interference and multipath fading, these issues were addressed in the next few advancements in the IEEE 802.15.4 protocol.

This protocol provides complete flexibility to the developers of the upper layer protocol. It provides support to majority of the upper layer protocols including IPv4 and IPv6.In the case of IPv6 the minimum MTU is 1280 bytes, but the complication of using IPv6 in IEEE 802.15.4 is that, the maximum MTU of IEEE 802.15.4 is 127 bytes, thus there is a need for fragmentation and reassembly of the frame. When fragmentation needs to be performed additional headers need to be added, thus increases the frame size. The frame format of this protocol contains a field known as the frame control. Frame control field contains a bit to enable security feature of this protocol. When the security feature is enabled, an auxiliary security header is added in the MAC layer payload.

Payload size is variable with a maximum size of 127 bytes. When the auxiliary security header is added there is a compromise in the available payload size. The size of the auxiliary security header is variable with a maximum size of 14 bytes. It provides AES encryption with128bit cipher key. IEEE 802.15.4 provides a maximum data rate of 250kbps and it also varies based on the modulation scheme used in the physical layer. There are many variations of IEEE 802.15.4 such as IEEE 802.15.4g, IEEE 802.15.4e and so on. The maximum MTU of these protocols are 2KB. These protocols can be used with devices which have ample buffer space. In this paper it is assumed that the available buffer space is very minimal. Thus, only IEEE 802.15.4 protocol is compared in this paper. IEEE 802.15.4 protocol supports IPv6 protocol but fragmentation becomes a necessity due to its minimum fragment size constraint.

B. *Adaptation Layer:*

Since the available buffer space in the majority of the IoT based device it is a requisite to optimize the various layers protocols and also on multiple protocols of the IP architecture. 6LoWPAN was the protocol developed to support low power noisy networks. It has the capabilities of header compression, fragmentation and mesh addressing. The headers are stacked such that the structural methods are enforced. Mesh header and fragmentation headers are optional and are combined when essential. Using the header compression algorithm, the header size is compressed to as low as 6 bytes. 6LoWPAN takes advantage of the shared information among the nodes of the network.

In addition to that some of the standard fields are also removed based on the assumption that standard values are used. When header compression is used in low power devices the efficiency nearly doubles. In intracell communication many of the fields can be removed assuming common values are used but when it comes to communication outside the cell certain extra fields will be needed without compression. Fragmentation headers are added only when required thus reducing tremendous amount of header size. Fragmentation header contains 1 byte datagram size, which tells about the size of the entire fragmentation header. It also contains datagram tag and offset header. To reduce the header size, offset header is not included in the first frame, thus improving available header space.

IV. PROPOSED FRAME FORMAT

In this paper it is assumed that the transmitter knows that the end device is a low power device with limited buffer size. The problem with the above protocol is that it uses encapsulation and provides flexibility to the upper layer developers, which introduces a few redundant bits in the frame. Encapsulation was used to isolate the devices layers in networking. But the problem is that encapsulation does not consider the buffer size constraint so it does not affect the normal devices but when encapsulation is used for devices with low buffer space encapsulation can turn out to be very costly. In this paper, detailed analysis of a new protocol is explained which can be used in specifically low power devices. In this paper it is assumed that the edge router is a smart device capable of taking decisions based on the packet which has arrived at the route from the network. Initially when a new end device is connected it will send an ICMP packet to the edge router notifying that it is a low power device and it requires header compression. When a new packet has to be sent to the low power device from outside the network, the entire IPv6 header should be sent and at the edge router the header is compressed before sending the frame. When a device from within the network wants to send a packet, then the frame is sent to the router and the router compresses it.

Fig.1. ICMP Packet

The above ICMP packet will be used to notify the router that it is a 6LoWPAN device. It will also be sent before every message sent. This is also used to implement dynamic variable size headers. In the frame shown in fig-1 is sent to notify if either Ethernet is used or Wi-Fi is used in the MAC layer. Then there is a 1 bit field specifies whether data is compressed. When the sender wants to send sensitive information which should not be compressed as it might cause some data loss, then this bit can be set to zero. Then the next field is the address size which specifies the number of bits in the address space. This field can turn out to be very helpful when there is continuous development in technology and the address space is increased. Currently it is a need that the entire network should support IPv6 address, but since it was designed for IPv4 it cannot understand IPv6 frames. This field helps in such situations. When there will be a development in the future and if the size of the address space increases then there will be no need to develop new protocols. By only changing the value in address size field new address space will be understood by the low power device. Flags field contains special purpose user defined flags. Since only control messages are being sent in through the ICMP packet and the size of the payload is very small, it can be accommodated without compression. Based on the frame format shown in fig-1, two more frames have been developed to support Ethernet and Wi-Fi in the MAC layer. If ethernet is used in the MAC layer then the frame format shown in fig-2 should be used and if Wi-Fi is used in the MAC layer then the frame format shown in fig-3 should be used.

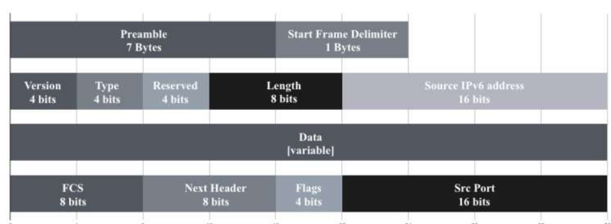

Fig. 2. Modified Ethernet Frame

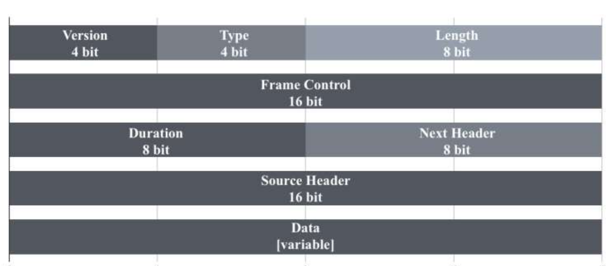

Fig. 3. Modified Wi-Fi Frame

All the fields are completely dynamic i.e. the size of each part of the frame format can be modified by the user by sending the appropriate values in the ICMPv6 packet. The header size in both the cases is reduced to 8 bytes which is the maximum header size. In the frame destination address is removed during compression because the device need not have to know about its own IPv6 address and MAC address. While communicating with the low power device there are

2 cases, the device which wants to communicate can be within the same network outside the network. If the device which wants to communicate is in the same network, then MAC address can be used to uniquely identify the communicating host. If the communicating device is outside the network, then only IPv6 address would be sufficient to uniquely identify the host. In the mentioned frame format the number bits assigned for port number, reserved, flags, frame check sequence and next header can be reduced based on user needs. This frame format is the base header. In case additional options such as fragmentation and security are required, then it can be added in the options field. Thus it isolates the base header from the options

V. RESULTS

The new frame format provided the following results. The number of packets dropped reduced, queueing delay reduced, throughput improved, bandwidth utilization improved. Buffer utilization was also increased due to reduction in the frame header size.

VI. CONCLUSION AND FUTURE WORK

Compared to the current protocol i.e IEEE 802.15.4 in the MAC layer along with the compressed network layer uses a minimum of 6 bytes but the size may increase. The best case scenario gives a header size of 6 Bytes but with the new proposed protocol, the maximum header size would be 8 Bytes and if the user shares the information of a few more fields then the frame size can be reduced even further. The best case scenario with the new proposed protocol would be 5 Bytes. Thus the new proposed protocol has a lower header size compared to the currently used protocol. In the new proposed protocol, the MAC layer header and the network layer header are combined and compressed to provide an efficient utilization of the header.

REFERENCES

1. Raoof and A. Matrawy,'The effect of buffer management strategies on 6LoWPAN's response to buffer reservation attacks', 2017 IEEE International Conference on Communications (ICC), Paris, 2017, pp. 1-7.
2. H. Shimada, T. Sato, K. Fujikawa and H. Sunahara,'Implementation and Evaluation of a Memory Management System for IPv6 Wireless Sensor Networks', 2008 International Symposium on Applications and the Internet, Turku, 2008, pp. 401-404.
3. ReenHummen, Jens Hiller, Hanno Wirtz, Martin Henze, Hossein Shafagh and Klaus Wehlre,'6LoWPAN Fragmentation attacks and Mitigation Techniques', 6th Conference onSecurity and Privacy in Wireless and Mobile Networks, Budapest, Hungary, 2013.
4. Samer A. B. Awwad, Nor K. Noordin, BorhanuddinMohd Ali, FazirulhisyamHashim and NurulHalimatulAsmakIsail,'6LoWPAN Route-Over with End-to-End Fragmentation and Reassembly Using Cross Layer Adaptive Backoff Exponent', 2018 Wireless Personal Communications 98, 1029-1053, Malaysia, 2017.
5. H. A. A. Al-Kashoash, Y. Al-Nidawi and A. H. Kemp,'Congestion-aware RPL for 6L0WPAN networks, 2016 Wireless Telecommunications Symposium (WTS), London, 2016, pp. 1-6.
6. S. A. B. Awwad, C. K. Ng, N. K. Noordin, B. M. Ali and F. Hashim,Second and subsequent fragments headers compression scheme for IPv6 header in 6LoWPAN network', 2013 Seventh International Conference on Sensing Technology (ICST), Wellington, 2013, pp. 771-776.
7. H. Harai and M. Murata,'High-speed buffer management for 40 gb/s-based photonic packet switches', in IEEE/ACM Transactions on Networking, vol. 14, no. 1, pp. 191-204, Feb. 2006.

BIOGRAPHY

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