Modified 6LoWPAN and UDP for IoT Devices

Name: Uday,nahin hossain
ID : 17-33297-1

Department: CSE
Institute: American International University Bangladesh

Name: Hasan, Mohd. Mahdi

ID:17-33599-1

Department: CSE
Institute: American International University Bangladesh

Name: Mim, Kanis Rahela
ID:17-34816-2

Department: CS
Institute: American International University Bangladesh

Name: Ahmed Naznin

ID: 15-29530-2

Department: CSE
Institute: American International University Bangladesh.

Abstract

In 6LoWPAN, packet transferring TCP protocol is time-consuming. So UDP is vastly used for 6LoWPAN but UDP is not reliable which can cause major problems when IoT is used in a greater range. The RUDP is a reliable connection-oriented protocol, which uses a three-way handshaking to overcome errors in connection and a resending mechanism for packet loss. So we proposed a modified version of RUDP which will include a serialID in the header. Several sets of experiments were taken into consideration to analyze the performance of the RUDP, compared with that of the RUDP to show the modified RUDP is faster and more reliable. We also perform an analysis of a routing scheme called Mesh in terms of the packet/fragment arrival probability, the total number of transmissions and the total delay between source and destination. An analysis observation of Mesh under routing was given by us. And the fitness of this routing under the 6LoWPAN network scenario.

Keywords: IoT, 6LoWPAN, RUDP, UDP, TCP, Mesh Under.

1. Introduction

Internet connectivity into physical devices and everyday objects is the Internet of Things which allows every device to communicate through the internet. Different forms of devices can communicate and interact with other devices over the internet with the help of IoT which can be remotely monitored and controlled. One of the emerging technologies supporting IoT is 6LoWPAN. 6LoWPAN has defined encapsulation and header compression mechanism that enables the use of IPv6 in IEEE 802.15.4 low power and wireless networks. That is, It can be applied in embedded applications for example monitoring, building automation, security, object tracking, nuclear reactor control, fire detection and traffic monitoring home automation, and even in several human-centred applications. The compression of IPv6 and headers is applied by UDP along with fragmentation and mesh addressing features. The compression of 6LoWPAN is very.

Simple, and thus stateless and reliable. This paper will discuss modified 6LoWPAN and UDP for IoT devices by proposing new characteristics for RUDP and comparing them with TCP and UDP. It will show RUDP will able to be faster and simpler than others. We also performed measurements on various numbers of packets and calculated the delay of packets to detect the packet loss.
This paper is organized as follows. Section 1 Introduction. Section 2 describes the background. Section 3 introduces the RUDP protocol and its characteristics. In section 4, experimental results of performance are presented in several aspects. Section 5, discusses the routing protocol. Section 6, shows the analysis. Section 7, shows the observation. Then we conclude in the last section.

2. BACKGROUND

The IETF standard[7] defines the overview, assumptions, problems and goals for 6LoWPAN. The packet size of IPv6 is larger than the MTU of the IEEE 802.15.4 data link layer. So the fragmentation and compression of IPv6 packets is necessary. Energy efficiency is an important issue for the transmission of 6LoWPAN. 6LoWPAN is an IETF standard about how to transit IPv6 packets over LoWPAN which is described in RFC 4944 [8]. In 6LoWPAN there is an adaptation layer between data link and network layers in TCP/IP protocol stacks. The mesh forwarding in the data-link layer is used to deliver an IPv6 packet from source to destination over a multi-hop scenario in 6LoWPAN. The one-byte dispatch value of the adaptation layer is employed to determine whether the frame is a LoWPAN frame or not. If the frame is a LoWPAN frame then specific headers types are taken place as part of dispatch value. The TCP is a time-consuming protocol for 6LoWPAN. UDP is vastly used for 6LoWPAN applications like home automation, automated factories etc. But UDP is not reliable which can cause major problems. And disappointment among the users.

3 Reliable UDP Protocol

In this section, we introduce the Reliable-UDP (RUDP) protocol with its characteristics which we developed specially for 6LoWPAN protocol and IoT devices. We also compare the major characteristics of UDP, RUDP and TCP.

3.1 The RUDP protocol we propose has the following characteristics to ensure reliable delivery between two parties:

- In order to establish a connection, the RUDP uses three-way handshaking with a serialID agreement.
- The serialID is used for the sequences of communication.
- If any serialID is missing the receiver sends and acknowledges to the sender.
- For recovery from a packet loss, the sender resends the same packet.
- In the meantime at the receiver's end, the last received serialID is formed into a loop.
- After receiving the lost packet the loop ended and the sequence continued.

3.2 Characteristic Comparison among the UDP, RUDP, and TCP

In order to compare the major characteristics of UDP, TCP, and RUDP protocols, we list out considerable issues which are valuable in communication Quality of Service criteria.

• Connection-Oriented: A process of negotiation occurs to establish a connection, ensuring that both communication parties agree on how data is to be exchanged.

•Reliable: This characteristic helps to keep track of data that has been sent and received by ensuring all transmissions are sent to their destinations.

• Bidirectional: Both communication parties on a connection can send and receive in bidirectional, regardless of which of them initiates the connection.

• Acknowledged: It is whether unsuccessful transmissions are acknowledged so that they can provide reliability.

• Stream-Oriented: This characteristic allows applications to send a continuous stream of data for transmission. Applications don't need to consider making this into chunks for transmission.

• Data-Unstructured: there are no natural divisions between data elements in the application's transmitted data.

• Data-Flow-Managed: This ensures that data flows evenly and smoothly, by dealing with problems that arise along the way.

3.3 Table 1: Comparison of Communication Protocol Characteristics [1]

Characteristics	UDP	RUDP	TCP
Connection-Oriented	No	Yes and fast	Yes but slow
Bidirectional	No	Yes	Yes
Multiply-Connected and Endpoint-Identified	No	Yes	Yes
Reliable	No	Yes	Yes
Acknowledge	No	Yes	Yes
Stream-Oriented	No	No	Yes
Data-Unstructured	No	No	No
Data-Flow-Managed	No	Yes	Yes

4. Experimental Environment

To measure the performance of the proposed protocol RUDP, we set up the following experimental environment.
The system topology consists of two machines: one for executing all clients and the other for executing the server. These systems were interconnected on an isolated network using a single network switch to remove unrelated traffic. Both server and client have the same system configuration as follows:

• Platform configuration:
o Java version for the project: Windows server 2003, Java(TM) 2 Runtime Environment, Standard Edition (build 1.4.2_04-b04), Java Hot-Spot(TM) Client Virtual Machine (build 1.4.2_04-b04, mixed mode)

• Network setting: Client and server are on the same network segment. 100Mbps Ethernet connection.

4.1 Performance Measurement on Various Numbers of Packets

In order to measure the performance improvement of RUDP compared to TCP, the first set of experiments is designed with various numbers of packets and having the same packet size. The client machine creates threads as many as packets are generated and transmits those packets toward the server. Thus, the number of packets is equal to the number of clients connected to the server. By increasing the number of packets, we measure the total elapsed time of transmitting packets. The size of each packet is 1024 bytes and the maximum waiting time is one second, where during the waiting time the RUDP client or server waits for the reply and it resends the serialID of the last packet.

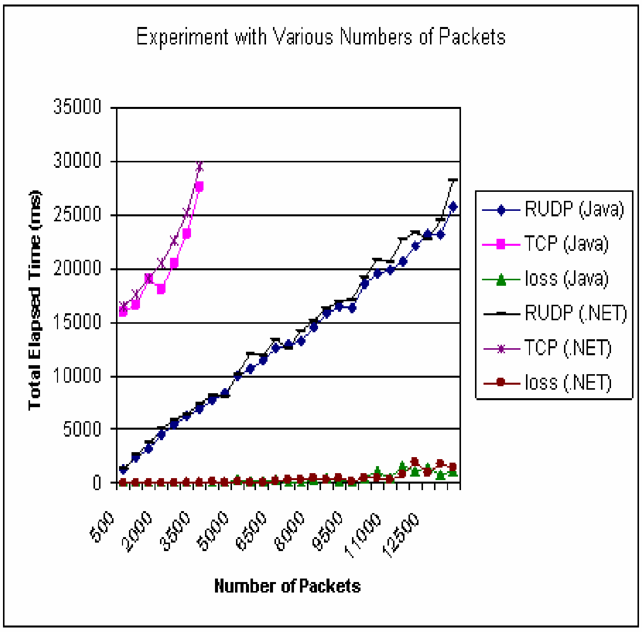

Fig 1 Performance Results with Various Numbers of Packets [1]

4.2 Performance Measurement on Maximum Limitation of Packets

TCP cannot establish TCP communication connections with the server. In TCP communication, a server cannot accept more than 4000 packets, since a server cannot create a large number of sessions. In contrast, the RUDP does not have any limitation to accept packets: the more the clients want to send requests, the more the RUDP can process.

4.3 Performance Measurement on Various Sizes of Packets

The next experiment is to measure transmission time by changing packet sizes. The same number of packets generated was fixed to 2000 and the maximum waiting time is 1 second.

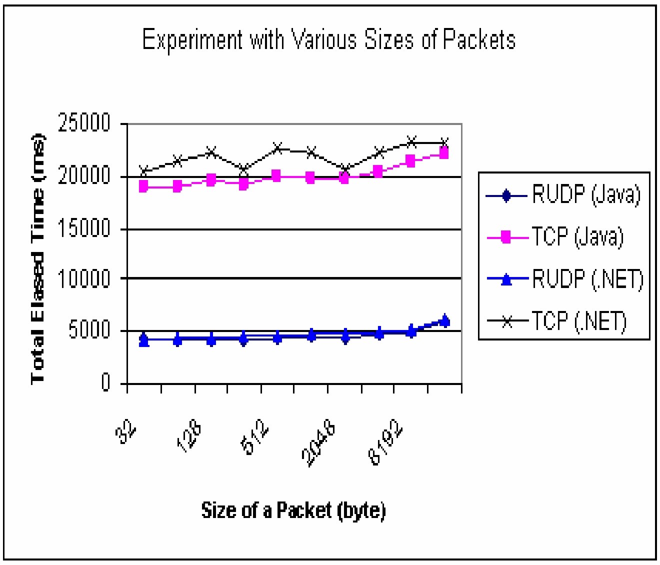

Fig. 2 Performance Results with Various Sizes of Packets[1]

4.4 Performance Measurement on Various RUDP Waiting Time

In this set of experiments, we want to observe the effect of the RUPD waiting time on the overall performance. We changed the maximum waiting time of RUDP from one second up to ten seconds in this test set. The size of a packet is fixed to 1024 bytes and we test with two different sets: one with 2000 packets and the other with 5000 packets.

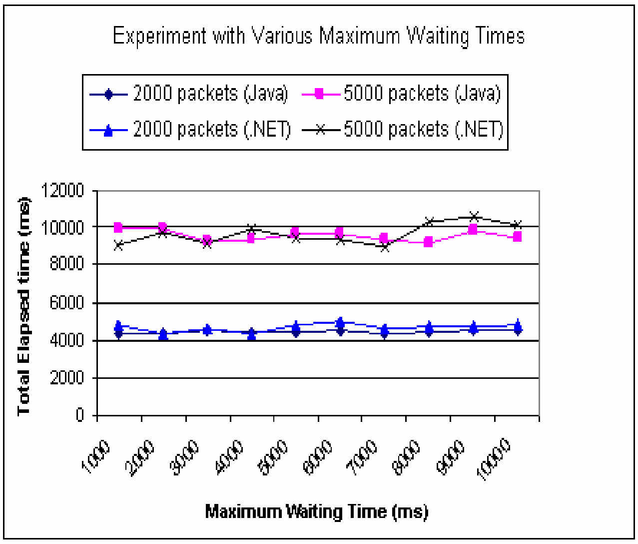

Fig 3 Performance Results with Various Waiting Times [1]

5. ROUTING IN 6LOWPAN

The routing protocol in 6LoWPAN is very sensitive because the capabilities of nodes are limited and the domain is fixed. Based on which layer the routing decision, Routing protocols in 6LoWPAN can be divided into two categories. The mesh-under and the route-over. Here we will give an analytical overview of Mesh-under routing.

5.1 Mesh-under Routing

In the mesh-under routing scheme, routing functions are placed at the data link layer. It is based on the IEEE 802.15.4 frame structure and the 6LoWPAN header [2,8]. All fragments would be sent to the next hop by the mesh routing protocol and reach to destination. Different fragments of one IP packet might reach the destination via different routing paths. If all fragments are received at the destination side successfully, the destination's adaptation layer re-assembles all fragments into a desired IP packet. However, In the forward process, for missing fragments, all fragments of this IP packet are retransmitted from the source.

6. ANALYSIS

In this section, we find out probabilistics for mesh-under schemes. Let's assume that a received IP packet from the network layer is divided into f fragments by the adaptation layer of the receiver end. Also, assume that h is the number of hops travelled by each fragment from source to destination.

6.1 Probability of Arrival of a Fragment

Let's assume that In a single attempt p is the probability of successful arrival of a fragment in one hop distance. N is the number of tries to send a fragment to the next hop. So, after N times retries the probability of reaching a fragment, P, to one hop distance is given by Eq. 1.

P =N Xi = 1

P (1−p) i−1 …….(1)

6.2 Total Transmission of Packets

Let's assume that the shortest routing path is characterized by the arrival of successful messages at intermediate nodes between the source and the destination. Starting at ith - intermediate node, make before reaching either source or destination 0, n, respectively. Here we would call this quantity m*i, i = 1,...,n − 1. The probability of jth, j ≥ 1, successful arrival of the message at any intermediate node. The number of intermediate nodes/hops required for communication with final destination will be calculated. Let B in Eq. 2, be the minimum number of intermediate nodes between source and destination.

B = Min{m : {m X j=1

Xj = −i_ j X j=1

Xj = n−i}}……. (2)

The total expected number of successful transmissions in mesh under Eq. 3.

E[B X j=1Xj] = pE[B]−q…… (3)

Here E[B], Eq. 4, denotes the expected number of fastest ferries and E[PB j=1 Xj] represents the expected number of successful transmissions from the source to the destination. The successful routed packets,(in Eq. 3), depend upon the geometric probabilistic distribution at each hop.

B X j=1

Xj =   n−i…,(with prob. α −i, with prob. 1−α)

(2p−1)E[B] = α−i…… (4)

E[B] =1 2p−1(n[1−(q/p)i] 1−(q/p)n −i)……. (5)

p is the probability of successfully receiving and forwarding the packet/fragment while q = 1 - p is the failure probability at each hop.

6.3 Total Delay Between Source and Destination

Here, Twat is the waiting time in the contention period. Tper is the propagation delay of a fragment and Tnode is the node processing time of a fragment. Now hop is the number of hops to be traveled and fr is the number of fragments. The total end-to-end transmission delay, Ttot, is:

Ttot = (Twat + Tper)hop + Tnode(hop−1) + (fr −1)(Twat + Tper) ……..(6)

In Eq. 6, (Twat+Tper)hop is the sum of the total waiting time in a contention period and the total propagation delay, Tnode(hop−1) is the total node processing time, and (fr − 1)(Twat + Tper) is the total waiting time for all fragments except the first one for all nodes in the route.

7. OBSERVATIONS

From the probability analysis, It is observed that no creation of an IP packet is done at the intermediate node and each fragment goes to the destination individually. So, the probability decreases after travelling each hop. There is no possibility of buffer overflow at intermediate nodes in the mesh-under scheme. In the case of the total delay, the mesh-under scheme does not have any overhead of reassembly and fragmentation at intermediate nodes but if the size of the IP packet is very large or the number of hops in the routing path is greater in number, then it has higher probability to lose fragments while routing. So, for small IP packet sizes or less number of hops like home automation or other IoT applications mesh-under scheme may perform better. There is more probability of losing fragments in the path Mesh-under scheme when it is a noisy environment.

8. CONCLUSION

The next generation of computing technology will be outside the realm of the traditional desktop. In the Internet of Things (IoT), many of the objects that surround us will be on the network in different forms as not in the present time. The use of radio frequency like Z-wave and wireless sensor network(WSN) technologies will rise to meet this new challenge, in which information systems and communication technology are invisibly embedded in the environment around us. Smart device connectivity with existing network computation using network resources is an indispensable part of IoT. However, vision of the Internet of Things is to successfully emerge, the computing criterion will need to go beyond traditional computing scenarios that use portables or non-portable devices and evolve into connecting everyday existing objects and embedding artificial intelligence into our environment. The new framework also has some major challenges introduced ranging from appropriate interpretation and visualization of the huge amounts of data. Through to the privacy, security and data management issues that must underpin such a platform for it to be genuinely viable. International initiatives are quite clearly accelerating progress towards IoT, providing an overarching view of the integration and functional elements that can deliver an operational IoT system over the world. The World Wide Web connected us all. Using the internet IoT will also connect us all including living and non-living things.

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