

Performance Analysis of 6LoWPAN Routing Protocols for IoT

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Abstract — Internet of Things (IoT) is the evolving technology in in the field of communication and it is used in various applications like weather forecasting, home appliances, health care, traffic management and etc. These applications comprise of many resource constraints devices like sensors, smart phones, fans, tube lights, which are connected to internet. The major standard used for communicating resource constraint devices is Ipv6 Low Wireless Personal Area Network (6LoWPAN). In this paper we are comparing 6LoWPAN routing protocols such as 6LoWPAN Ad-Hoc on-Demand Distance Vector (LOAD) ,6LoWPAN Dynamic MANET On-demand Routing protocol (DYMO-Low) and 6LoWPAN Ad-Hoc on-Demand Distance Vector – Next Generation (LOAD-ng) protocols. This work aims to analyse the performance and the need of efficient protocols for data flow management, security, and power optimization in IoT.

Keywords- IoT, 6LoWPAN, LOAD, DYMO-Low, LOAD-ng.

I. INTRODUCTION

Internet of Things (IoT), also called as machine-to-machine (M2M) (where smart devices take action immediately and automatically by collecting information, transmitting information to one another, processing the information collaboratively) is a new communication model, which offers both chances and challenges [1]. The Fig.1 gives the more knowledge on Internet of Things.



Fig. 1 – Internet of Things

Always, humans keep demanding technologies to save money and time. Basically, human beings want to be happier, human beings becomes more happier when they have following things, First, humans want further time and money to lead the life joyfully and improve the quality of life. Use of Technologies helps in saving money, enhancing their appearance and eating better. Second, most of all the human beings want to escape being in nasty situations.

Technologies like estimation of environmental changes or fire warning systems helps in predicting the future events. Third, human beings hunger to be healthier.

Earlier it was very difficult to identify the information flowing in network but now more network altering capabilities are budding. First, different natures of sensors improve our perceptual skills by sensing information that humans not able to sense and gather such information anytime and anywhere. Second, robots advance our skill to perform better where humans cannot reach by overcoming physical limitations during natural disasters. Robots can perform better-than-human skills, for example robots were used to explore the destruction caused by the nuclear plants due to radiation in japan [2]. Third, wireless communication and broadband technologies increase our quality of communication facilities only when 4G wireless [3] and improved internet bandwidth become available. Fourth, growing cloud computing and machine intelligence technologies will improve quality of analytical skills by gigantic computations and advanced machine learning practices.

Technologies provide information on human's well-being and environmental hazards, to take care of geriatric and unhealthy people, and to escape accidents and injuries. Fourth, most people wish for friendship, using E-mail, smart phones and social networks like face book, twitters and WhatsApp and etc., which connect people. Ultimately, people need to be extraordinary and to be appreciated [1]. The emerging M2M technologies fulfil the above listed human wishes [4] [5] [6]. For example, imagine that you are going to give a talk in continued medical education program in another metropolitan city and you got stuck traffic. Improvement in communication technology enables your calendar and your car can link together and your smart phone automatically sends message to your audience regarding delay in arrival.

II. 6LoWPAN Overview

The basic communication capabilities of physical radio are formed by physical layer, which is built on IEEE 802.15.4 with a data rate of 250 Kbps. The rate of functioning frequency is 2400 – 2483.5 MHz's. The reliable, single-hop communication links between devices are provided by the Data Link layer, the MAC PDU is IEEE 802.15.4. IEEE 802.15.4 networks are not necessary to run in beacon- enabled method. In non-beacon enabled networks, contention-based unslotted CSMA/CA channel access method is used to send frames.

6LoWPAN Applications
No External use
No External use
Transmission Control Protocol / User Datagram Protocol
IPV 6 and Adaptation Layer
IEEE 802.15.4 (un-slotted CSMA/CA)
IEEE 802.15.4 PHY

Fig. 2 – 6LoWPAN Stack Architecture

In 6LoWPAN devices adaptation layer is the significant constituent. The first foremost task of this layer is to compress TCP/IP header. For IEEE802.15.4, TCP/IP headers are too lengthy. The size of the TCP/IP headers is 128 bytes whereas IPv6 header size is 40 bytes. The size of the UDP and ICMP headers are of 4 bytes and TCP header occupies

20bytes. For effective transmission of any payload compression of TCP/IP headers (802.15.4) are mandatory. A second task is to handle packet fragmentation and packet reassembling. The maximum frame size of IEEE 802.15.4 is 128 bytes, but maximum transmission unit (MTU) of IPv6 protocol is of 1280 bytes [7], this disparity is handled in the adaptation layer. The third task is routing. The IPv6 packets are routed by the border nodes of the WSN from outside to inside the network and vice versa [1][8][9]. The architecture of the 6LoWPAN is given in the figure Fig.2.

III. 6LoWPAN Routing Protocols

LOADng, LOAD, DYMO-Low are the 6LoWPAN protocols used widely in IoT. These low power routing protocols implemented based on the idea of Ad-hoc on demand Distance Vector Routing protocol (AODV), disadvantages such as routing table construction and packet processing time affects the performance of LOAD-ng, LOAD and DYMO-LOW.

1. Ad-Hoc on-Demand Distance Vector – Next Generation (LOAD-ng)[8]

AODV routing protocol is the basis for LOAD-ng, which uses the reactive approach. In reactive approach, whenever data to be send then only it creates the routes towards destination. In LOAD-ng whenever node wants to send data it checks the routing table for the possible route to the destination. To find feasible path LOAD-ng floods the RREQ message in the network. Once node receives the RREQ message, the node checks for the destination node by itself, If not it forwards the RREQ to neighbouring nodes. When destination node receives the RREQ message it responds to the request originator by unicasting the RREP message [8].

The main drawback of the LOAD-ng is delay in the route discovery. During route discovery phase outgoing packets are buffered in the nodes, this may cause the packet loss in the resource constraint devices. The nodes are suffered from energy depletion because of flooding. Another drawback of this protocol is collision. Packet collisions are more due to the flooding, which leads to redundant retransmission of data [8].

2. 6LoWPAN Ad-Hoc on-Demand Distance Vector (LOAD)

LOAD protocol uses 16-bit address; discover the route using broadcast technique. It does not use destination sequence number. Destination replies to RREQ by RREP. Whenever there is a link break occurs node reports back to the originator [11].

LOAD protocol functioning on top of the adaption layer rather than transport layer. In IPv6, mesh network topology is formed by the LOAD protocol. In LOAD, if any link breakdown occurs, LOAD protocol tries to repair the route locally by finding the new route. In LOAD during route discovery phase Route Request (RREQ) messages are broadcasted and RREP messages are unicasted. If broken links are not repaired by the repairing node, the RERR packet is unicasted by the repairing node to the originator with an error code that indicates the reason for the repair failure in the network. Thus no require for any precursor list [11].The figures Fig.3, Fig.4, Fig.5 illustrates the RREQ, RREP and RERR respectively.

TYPE	R	D	O	RE SERVED	CT	WL	RREQ ID	Route Cost
RC	Link Layer Destination Address							
Link Layer Originator Address								

Fig. 3- Route Request Message Header Format (RREQ)

It is possible to handle the link breaks in three ways in LOAD. One way is by using the source address of data packet to send RERR to the originator. Node on Sending RERR to the originator and second way is Unicast RERR back only to the previous hop node. Third approach is broadcast the RERR back by utilizing the routing table entries [11]. Header format of the RREQ message include following fields and showed in Fig.3.

T Y P E	R	D	O	R E S E R V E D	C T	W L	R R E Q I D	Route Cost
RC	Link Layer Destination Address							
Link Layer Originator Address								

Fig. 4 - Route Reply Message Header Format (RREP)

TYPE	D	Reserved	Error Code
Unreachable Link Layer Destination Address			

Fig. 5 - Route Error Message Header Format (RERR)

Type-1 this field indicates type of the message.

CT – This field indicates the kind of route cost. To avoid weak links, the rest of 4 bits is set with TBD.

WL –This field specifies the total number of weak links in the M2M network along with the path from the source to the present node.

R - This field is used to show local route repair. This field set to value 0 when the message is not generated during local repair.

D – This field is of 16 bits address which is used to store destination address, 0 for the EUI-64 address of the destination.

O - This field is of 16 bits is used to store the originator address, 0 for the EUI-64 originator address.

RC (Route Cost) – This field is used to keep track of link cost from the originator to the current node in which type of route cost is specified by CT.

RREQ ID – is unique identifier which is uniquely identified by a sequence number in conjunction with the originator.

Reserved - 0, now not in use.

Link Layer Destination Address – This field contains the destination address of a node.

Link Layer Originator Address – This field contains the address of the node that originated the RREQ.

The RREP and RREQ header formats having the identical fields. The field type is used to specify the type of the message used by the network, if type field is set to 1 then the message is RREQ message, if type field is set to 2 then the message is RREP message, if type field having the value 3 then the message is REER message. The header format of the RREP message is given in the Fig.4. The RERR message is composed of fields given in the Fig.5. The WL and RC fields are used to signify the total number of weak links in the network and the total route cost from the originator of the RREP to the current node. The fields D having the value 1 for 16 bit destination address and 0 for the EUI-64 address of the destination. The Error code field is used to describe the type of an error that occurred. Data message cannot be accelerated towards its destination is the only type of RERR message available in the LOAD routing protocol. When destination node becomes unreachable due to link breakage, Link Layer Destination Address field is used to specify destination address.

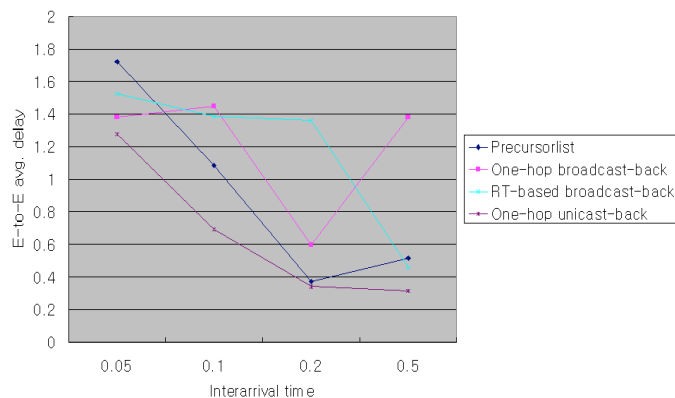


Fig. 7 – END to END Delay in LOAD

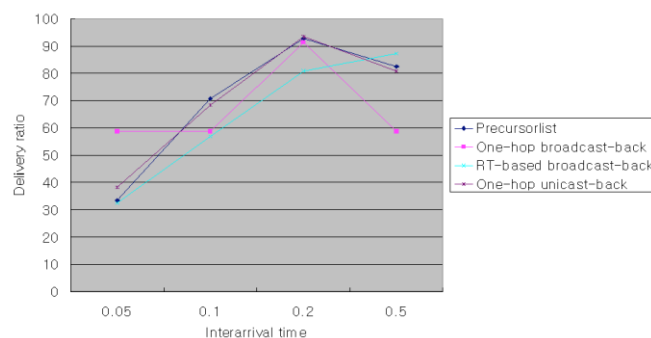


Fig .8 - Packet Delivery Ratio in LOAD

3. Dynamic MANET On-demand for 6LoWPAN Routing (DYMO-Low)

DYMO-Low uses the Broadcast mechanism to route the packets. Only destination node responds to the source node. It also minimizes the number of control messages change between the source, destination and the

intermediate nodes by aggregation. The protocol does not use the hello message and the sequence number.

The DYMO protocol implemented based on AODV routing protocol. In DYMO protocol route discovery and repairs are based on RREQ, RREP and RERR message. At the time of route discovery phase, RREQ and RREP message gathers routing data from intermediary nodes. To keep track of the link connectivity DYMO uses the Hello messages but not in local link repair. User Datagram Protocol (UDP) is used as base protocol, using which DYMO is placed on internet protocol (IP). Due to memory constraints and power consumption, DYMO is not directly placed on low power devices. Hence, DYMO can be replaced by DYMO-low. To construct mesh network topology of 6LowPAN to IP devices, DYMO-low directly functions on link layer. So that IP recognizes WPAN as a single link. DYMO-low makes use of 16-bit short link layer address or IEEE 64-bit lengthy address (EUI-64) [12].

DYMO-low features are same as LOAD except 16-bits sequence numbers, which are used to ensure loop freedom. In LOAD, local link repair and route cost information are used, but not in DYMO-low [13]. Comparison between 6LoWPAN Routing Protocols LOAD and DYMO-Low are listed in Table 1.

Table.1 - Comparison of LOAD, DYMO-Low and LOAD-ng

PARAMETERS	LOAD	DYMO-Low	LOAD-ng
RERR Message	Used	Used	Used
Sequence Number	Not Used	Not Used	Not Used
RREP Message	Used	Used	Used
Hop Count	Optional	Optional	Used
Hello Message	Not Used	Not Used	Not Used
Local Repair	Not Used	Not Used	Not Used
Energy Usage	Low	Low	More
Memory Usage	Low	Low	Low
Link-Layer Feedback	Used	Used	Not Used
Control Packet Aggregation	Not Used	Used	Not Used

IV. CONCLUSION

This paper highlights the performance of different 6LoWPAN protocols such as LOAD-ng, LOAD and DYMO-Low. The performance of the LOAD-ng protocol drop downs because of collision in the network and energy depletion. Performance analysis of LOAD protocol along with the header formats exhibited successfully and Comparisons between 6LoWPAN routing protocols such as LOAD-ng, LOAD and DYMO-Low for internet of things presented effectively. Since LOAD-ng, LOAD and DYMO are built based on the AODV protocol, the problems associated with the AODV routing protocol like packet processing time, as the packet processing time increases delay in network also increases and RREQ and RREP packets puts more load on the network.

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