A Survey on Multicast Reliability Issue of IoT based Routing Protocol

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Abstract— Present Vision of IoT is to utilize the objects in a smart manner by connecting them through the network. The future vision of the smart city and digital urbanization has come true through this trending networking technology. It uses the number of monitoring or sensing devices having low power consumption. Moreover, the network created by them having the 'lossy' characteristics in terms of link and data-packets, for this type of network RPL has been introduced. RPL is designed to be a convenient and inter-operable networking protocol for resource-constrained devices in industrial, domestic, and city-level environments, intended to support the vision of the Internet of Things (IoT) with thousands of nodes and sensors, interconnected through multi-hop different networks topologies. Although, RPL having some challenging issues i.e. functional and working related. One of them is multicast Reliability issues that arise during the up-down routing (forward routing). In this paper, we present the literature related to work that has been done to overcome reliability issue of the multicast functionality of RPL. Further, we gave more focus on Existing approaches that having the disadvantages like time delay and transmission overhead. Furthermore, our objective is at the end determine the approach that gives efficient reliability to the multicast functionality of RPL and makes the whole LLN reliable.

Key words: RPL, IPv6 Routing Protocol, Internet of Things (IoT), Low Power and Lossy Network (LLN)

I. INTRODUCTION

Technology that makes daily working fast with few efforts. Although the evolution of technology also made things to do the operations with the semi-automatic mode that only need the manual operative system and maintenance after a long time of usage. Wireless Sensor Network (WSN) is a propelled innovation which comprises an arrangement of sensor hubs. These sensors are in charge of detecting and gathering information frame condition in which they sent. This data is additionally transmitted to the base station (BS) by means of the steering convention. Vitality dispersal is a noteworthy concern while information transmission is finished. Different directing conventions are utilized to decrease vitality utilization in WSN. Various leveled routing protocol is considered to lessen vitality utilization. A technological approach that makes the things of everyday usage automatic operative that usually having the manual operation to get the work done. A technology that changes the perspective and vision with its advantages and ease of usage. In that category of protocol, one of them is LEACH [1]. For this protocol many types of research done on it and derived its cons, working on them and having their own approach to LEACH protocol. MMR-LEACH [2] and E-LEACH [3] works on the issue of cluster head selection and load balancing. Through this, they can increase the lifetime of the network. Despite WSN, Revolutionary technology has been coming to change the scenario of technology through the conceptual level. That technology is the Internet of Things (IoT). The establishment is easy, Implementation cost Low, Maintenance less than old technology and outcome is more effective these matter a lot in the technological world and also all these features given by IoT. IoT brings the whole world to the top of the screen and we can use it with the tip of the finger. It works on the concept of the wireless sensor network. In general, IoT, Network having the entities as nodes and all the nodes having in some small as well as same network. For large scale interface systems nodes having their integrated network structure that manages the operations. Nodes are made up of its machine elements, power supply or battery and sensors. We can say that Sensors are the heart of IoT. The network that made up with this type of node is Low power and Lossy (LLN) in nature. Generally, wireless sensors network having the protocols for its characteristics e.g. Integrity, Security etc. and its operations e.g. routing. But LLN not having same characteristics so that predefine protocols are not efficient for this kind of Network.

A. RPL

Internet Engineering Task Force (IETF) and Routing over Low power and Lossy Network (ROLL) defined the characteristics of this type of network that nodes are constrained node that having the low power of processing, storage, and battery. Also, it is the Lossy in terms of the data packet and link loss. Routing particular in this type of the constrained and large-scale network is a challenge for that. Because other protocols that related to routing are not effective or operative as much as we required IETF and ROLL working group designed protocols especially for this type of network. Routing Protocol for Low power and Lossy Network (RPL) has been proposed and standardized in 2012, having Standard Documentation as RFC-6550. [4] RPL is a distance–vector (dv) and a source routing protocol that is designed to operate on top of several link layer, PHY, and MAC layers. The goal of RPL is to provide ipv6 connectivity to a large number constrained (i.e. lossy links and high packet error) devices and nodes of LLNs in industrial, home, and urban environments. It is also having their pre-defined Mode of Operations (MOP) [5].

- MOP 0: No Downward path kept up by RPL. This mode just backings multipoint-to-point activity for which node can send data-packs to the RPL tree's root.
- MOP 1: It is Non-Storing Mode of Operation. Downside paths are upheld however all IPv6 data-packs ought to be sent to the root which keeps up every single Downside path.
- MOP 2: It is Storing Mode of Operation, in which multicast feature is not present. The individual nodes support downside paths by maintaining a routing table for their following nodes.

– MOP 3: It is Storing Mode of Operation, in which multicast feature present. Similar to the previous MOP with the addition of supporting point-to-multipoint network traffic flows.

Multicast is an essential property of any wireless sensor network that having the point to multipoint characteristics of the mode of packet routing. RPL also having the multicast support that resides in its mode of operation (MOP 3) and optional for nodes in nature. But LLN having some issues regarding the reliability of the multicast operation in RPL, although some of the solutions are to overcome it need research work to get better performance of the multicast operation.

II. TECHNOLOGY DEVELOPMENT

A. Computing Platforms

Contiki [6] is an operating system that has the environment like Ubuntu and especially used for networking related application and projects. It is started by Adam Dunkels and its developers are from different well-known networking firms. Basically, its code is written in C language under BSD license. It is memory efficient operating system that used 2kb of RAM and 40kb of ROM minimally. It Provides IP support to IPv4, an IPv6 form of uIPv6. It also supports multithreading as well as protothreads. Contiki used as the operative system for fighter ships, satellites, oil drilling equipment and digital TV decoder etc. It's working environment for arranged, memory-compelled frameworks with an emphasis on the low-control remote Internet of Things gadgets. Surviving usages for Contiki consolidate structures for street lighting, sound checking for adroit urban groups, radiation watching, and alerts.

The Contiki operating system provides inbuilt network simulator called Cooja [7], which simulates networks of Contiki nodes. The nodes may belong to either of three classes: emulated nodes, where the entire hardware of each node is emulated inbuilt in the simulator and operating system, Cooja nodes, where the Contiki code for the node is compiled and executed on the simulation host, or Java nodes, where the core framework of the node must be re-implemented as a Java class. One Cooja simulation may contain a mix of nodes from any of the three classes. Emulated nodes can also be used to include non-Contiki nodes in a simulated network. Cooja is basically developed in Java and also support multi-threading programing mode. Moreover the features of Cooja Simulator is 'Collect View' that collects the sensor data and prepares graph for that processed data. For real-time simulations Cooja having default feature of the collect-view. Although For RPL, Contiki and Cooja Combination is supportive to it and having some of the features modules for inside its file system.

III. RELATED WORK

Suresh et al. [8] authors survey some of the standard and non-standard protocols that are used for network routing in IoT applications. Six routing protocols RPL, CTP, LOADng, LOAD, CORPL, CARP, and E-CARP in IoT were studied in this paper. In the conclusion, they were stated that 'RPL is the most commonly used protocol among all of them'. Moreover, the comparison has been done over some characteristics of the network like server technology, security, and management aspects. They also showed the results (regarding introductory information and general advantages) and simulation related information that useful for the implementation purpose. Although in the beginning the characteristics of the network, Evolution to IoT, characteristics of IoT, issues that arise due to the change of the simple networking concept to the IoT and application of IoT these topics and concepts have made. In the conclusion part, they were stated RPL is popular but that is on the basis of usage not on the basis of characteristics, all the pros and cons were discussed but not concluded among them that which protocol is used in the IoT Network on the aspects of range, scale, and other network related approach. The informational and general survey done by them, although it is good for the new researchers.

R Jain et al. [9] authors discuss distinctive norms offered by IEEE, IETF, and ITU to empower coordinating the technology and the fast development in IoT. These Protocols having features like sending-receiving process of packets, Route management, network and session layers of the systems administration stack that are being produced just to meet necessities of IoT. Additionally, authors have stated that these standards and protocols are incorporated for administration and security conventions. Also gave a short comparable parameter related information on various IoT standards that helps to choose the appropriate protocol for related application or project. Finally, they discussed some challenges that still exist in IoT systems and researchers are trying to solve them. All-over this survey paper has complete information about the protocols has been used in IoT at different levels of network architecture. Some brief information with some working mechanism gives more clarity towards concepts of protocols.

Olfa Gaddour et al. [10] authors have introduced the nature and hierarchy of the technology that firms wired to the wireless network and now at IoT. Moreover, the characteristics of the LLN discussed in detail also. Further, the concept of the RPL has been elaborated in the specific sections are standardization, conceptual structure, importance, formation of network, control messages, mode of operations, message headers, working with the example, network management related concepts and performance evaluation of RPL. On the basis of the performance evaluation, they have suggested some routing protocols that implemented early for the wireless sensor network. From that perspective, they compare all of them on the basis of topology, scalability, mobility, memory usage, energy usage traffic support etc. At the end, they discuss the related problems and challenges for the future research work.

Hyung-Sin Kim et al. [11] authors initiate with the concepts of the IoT, wireless sensor network and LLN characteristics. Next, to them, RPL related introductory as well as some brief and deep information provided. The core part of this paper is the statistical and analytical summary of the work that related to RPL has been provided first in the form of the table that contains the Number that fills the cell between the year and particular work field, also the simulation and OS related facts and figures given also in the table. Afterwards, the related work of the RPL discussed in a deep manner. Issues elaborated first than related work that already done that stated by the increasing order of the year.

At the end of every discussion, they have the key points knows as the standard discussion and that problem or challenge raised during the discussion that provided the implication. This paper is made of the combined information of the 97 papers that related to the RPL.

George Oikonomou et al. [12] authors have introduced initially the concept of the IoT. Afterwards, they give the introduction and brief information about the multicast operation in the traditional wireless sensor network and its importance towards the network. RPL having two types of packet forwarding operations that upward-downward forwarding. In the downward forwarding and P2MP mode of operation, multicast has been supported in the RPL. For the multicast mechanism, two approaches have been stated, Trickle Multicast (TM) and Stateless Multicast in RPL Forwarding (SMRF) both used in RPL. Both concepts have been explained with the introduction, working and pros and cons. Although the information related to the performance evaluation also given by the no. of perspective e.g. topology, No. of nodes, time interval etc. between TM and SMRF. At the conclusion part, they have stated that the multicast forwarding has been liable for the usage of the sensor and nodes, although they provided the comparison based analysis so the user can use as per requirement.

Khaled Qorany et al. [13] they have presented a new approach of RPL multicast-forwarding called ESMRF. It is a revised and updated technique of SMRF which give a helpful idea to overcome a strong limitation of its sending operation. Also, they have stated that ESMRF has the same performance with SMRF if the examine node of RPL is a generator of multicast traffic and gives a effective outcome in the case of the highest rank node is the source of multicast traffic in that case SMRF nit worked in an effective manner to deliver the packets. In a random topology, ESMRF performs functions and tasks better than TM and SMRF. Additionally, they are currently researching and developing an efficient service discovery scheme using ESMRF for usage in 6LowPAN. Moreover, the ICMPv6 packet related herder information and structure also discussed that transfers from the DODAG member to the root.

Bart Lemmens et al. [5]: authors discussed BMRF, a multicast forwarding approach for IPv6 based LLN environment, which addresses some of the problems and pitfalls of the currently available protocols and standards. BMRF operates in different 3 modes for its sending operation i.e. unicast, broadcast and mix-mode. Moreover, it allows sources of multicast traffic to be located inside the network and also supportive to the selective multicast group subscription, although it takes slightly higher memory consumption. Moreover, the proposed approach is configurable in terms of energy consumption, latency, and reliability. Although practical evaluation shows the proposed threshold for BMRF Mixed mode succeeds in getting the best of Link Layer broadcast and Link Layer unicast.

Kittithorn Tharatipayakul et al. [14] authors initially discuss the conceptual information about the IoT. Afterward, the WSN and multicast related scenario have been discussed in terms of the years and methods that used to archive multicast in RPL. They have introduced one new concept iACK [14], the multicast technique that overcomes the cons of the previous techniques Trickle Multicast and SMRF, although they remain the usage of the SMRF as the part of the mechanism. They show the scenario that in multicast the explicit acknowledgment is used that made the delay and packet overhead also. So they come up with the idea of the implicit acknowledgment that nodes that having the same rank and having the member of multicast group retransmit the packet among them that considered in the neighbor propagation operation. A specific static buffer memory is given to that node that stores the no. of the packet that retransmitted at the specific time interval. Moreover, the retransmission list management and retransmission time-related variables and constant values have been also discussed. Simulation results show iACK has considerably higher data delivery ratio compared to both SMRF and TM, and lower delay than TM (and only slightly larger than SMRF). A key point of iACK is that parameters can be adjusted to select an appropriate tradeoff between delay and delivery ratio depending on the scenario. A drawback of iACK is that it requires more memory in each node. Further analysis is needed to evaluate the memory usage and the performance of iACK in different topologies.

IV. RESEARCH CHALLENGES

Here we discuss the challenges that related to the routing protocol that facing the related work and related circumferences that take place to archive the reliability of the related work of the multicast. There are also some of the work that related to RPL e.g. scalability, mobility, and up-down forwarding are also having some serious issues regarding it but there also having some serious research solutions but multicast having mainly three issues.

First, the delay that is very crucial in the LLN but also in the RPL multicast. In the trickle multicast, it takes the predefined time interval to trigger the sequence number count mechanism and get the error or the missing node related information but is the time interval is more than between two interval period the packet might be lost or not get at the time that leads toward the integrity.

Second, the packet overhead condition. If we consider the scenario of the LB-Router that having the large amount and force of packet that has been deployed in the related network, but if the router is not capable to take that much of pressure than at the initial level we might lose the packets. This same scenario happens at the time of retransmission in iACK mechanism [11]. At that time of retransmission every neighbor node rebroadcast their buffered packets according to their retransmission list, but at the end, all the node must accept that packet once for checking purpose that thing might cause that packet overhead condition.

Third, the packet delivery ration. From the root the as per the multicast mechanism only one copy of the packet has been going through all over the network by the neighbor broadcast concept. But at the higher node sides having the lower packet delivery ration in compare to lower rank nodes. Moreover, they can recover that packet from the preferred parent but that might also the packet with the decreased strength of packet.

All of the challenges that might not be overcome in one approach but it's our best try to solve one of them in our

research work. Although the multicast related research work having little more focus on the decrement of the delay factor in the network, that might be visionary for the concept of as fast as to reach that leads towards low data loss and overhead.

V. CONCLUSION

As per the concept of the fractional value, Reliability is also the Fractional proportional quality of any kind of operation, mechanism or systems. Although reliability having the more important in any kind of evaluation of the performance. Early in the wireless sensor network that has been archived by Automatic repeat request (ARQ) and Forward Error Correction (FEC) methodologies. Here we talk about RPL and its related work than among all the functionality, we focused on multicast functionality. In that reliability of protocol in LLN means multicasting the packet should be reached at the node in minimum or optimum time and efforts. As previous. Related work satisfies one or more issues related to multicast reliability but none of them overcome all the issues. Although iACK [14] satisfies the reliability criteria and dose the multicast in a good manner, it is also having the issues related to buffer size and data-packet overhead. So, The RPL multicast reliability archived by newer or modified approach that may be traditional or novel that satisfy challenges that stated in the previous section that should be near to overcome all of them or get the performance result better than all previous solutions.

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