A Survey on Multicast Routing Protocols for IoT Applications

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Abstract: Multicast is an essential component in many IoT applications. This paper presents the simulation and performance analysis of four different multicast routing protocols for Internet of Things (IoT). They are AMR6 (Advanced Multicast Routing for 6LoWPAN), M-CoAP (Multicast Constrained Application Protocol), Simple Agile RPL multiCAST (SARCAST), Enhanced Stateless Multicast RPL Forwarding (ESMRF) and for IoT. The performance of these protocols is compared in this work using standard metrics including throughput, reliability, packet delivery ratio, and end-to-end delay under two different scenarios: 1) changing the number of nodes, and 2) changing the traffic load. The major goal of this work is to choose one of four multicast routing protocols that is suitable and effective for IoT applications based on the relative strengths of each protocol. AMR6 achieves improved throughput, reliability, and packet delivery ratio with less end-to-end delay, according to experimental results.

***Keywords*:** Internet of Things (IoT), Multicast Routing, AMR6, M-CoAP, SARCAST, ESMRF.

1. Introduction

Internet of Things (IoT) is a connected networking devices, home appliances and vehicles that contain micro controller, sensor, communication modules and power sources which allows to connect, interact and transfer of data between these things [1]. Multicast is a type of communication process which supports group communication. The main objective of multicast routing protocol in IoT is sending a data to group of things [2].

There has been no survey on performance evaluation of the various multicast routing algorithms proposed for different IoT applications. This research provides an overview of four state-of-the-art multicast routing protocols for IoT applications performance evaluation. The major goal of this research is to determine which multicast routing protocol, out of AMR6, M-CoAP, SARCAST, and ESMRF [3-7], is the most effective for IoT applications. Therefore, it is crucial to assess the performance of four state-of-the-art multicast routing protocols in IoT applications in order to understand their behavior and efficacy.

1.1 Motivation and Justification

Although there are several existing surveys on multicast routing protocols for performance evaluation over MANET, WSN and Wireless Mesh Network (WMN), a few for IoT. This paper gives survey on the four state-of-the-art multicast routing protocol for performance evaluation for IoT. The major goal of this work is to determine which of these four multicast routing protocols is the most effective for IoT, taking into account each protocol's respective strengths and weaknesses. Therefore, it is crucial to assess the performance of four cutting-edge multicast routing protocols in the IoT in order to understand their behaviour and efficiency.

P. Levis et al [8] proposed a Trickle mechanism that performs intermittent data trade among adjoining hubs in a low force, lossy organization. It determines the powerful conduct of intermittent clocks. Stream gives a technique for proliferating state data productively, without continually flooding the organization with control messages. G. Oikonomou et al [9] developed an alternative to Trickle multicast Stateless Multicast RPL Forwarding.

1.1 Outline of the paper

The outline of the paper is presented in the Fig.1.

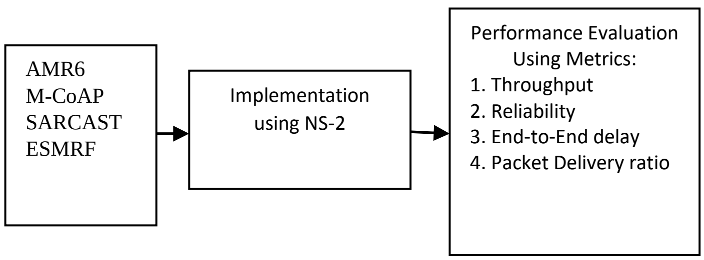

Fig.1 Outline of the paper

1.2 Organization of the Paper

This paper is setup in different sections. The multicast routing protocol is described in section 2. The simulation environment, performance indicators, simulation inputs, and simulation outputs are provided in Section 3. Finally, comparisons are explained in conclusion section.

2.0 Multicast Routing Protocols

In this section, descriptions of the four state-of-art multicast routing protocols (AMR6, M-CoAP, SARCAST and ESMRF) for IoT applications are given.

2.1 Advanced Multicast Routing for 6LoWPAN (AMR6)

In AMR6, a sender wants to send an IPv6 packet to a group of things ie. Multicasting, if few nodes are missing to receive these packets, it sends retransmission packet request to neighbour node. Neighbour node send reply with the missing packet using Modified Route over scheme [8]. AMR6 provides selective retransmission policy to multicast routing scheme with the help of request aggregation, therefore more efficiency and lesser number of transmissions is achieved than SMRF.

2.2 Multicast Constrained Application Protocol (M-CoAP)

In many IoT applications, Multicast CoAP plays an important role in constrained environment, for group communication, Multicast CoAP requests are sent to specific group using NONs (Non-Confirmable message), which does not require reliable transmission, this type of message is not acknowledged but has a message ID for duplicate detection. Security is not guaranteed in M-CoAP, since group communication based on NoSec (No Security) mode.

2.3 Simple Agile RPL multiCAST (SARCAST)

The Simple Agile RPL Multicast (SARCAST) idea actualized in this uses a coordinated tending to plan to diminish the adequacy of multicast-put together DoS attacks with respect to IoT gadgets. The Internet Engineering Task Force (IETF) has determined such a convention in the IPv6 Routing Protocol for Low-Power and Lossy Networks (RPL) [5], which is intended to make Destination-Oriented Directed Acyclic Diagrams (DODAGs) for the motivations behind sending message traffic to the basic root. Since RPL gives the routing core to these gadgets, it turns into a key viewpoint of the systems administration framework and structures the reason for the investigation of a lot of this work [3]. As DoS assaults may pervade the cover of the IoT from the more extensive web, it is imperative that this class of gadgets can moderate the adequacy of such an assault on an RPL-driven organization

2.4 Enhanced Stateless Multicast RPL Forwarding (ESMRF)

ESMRF is an alternative multicast transmitting component for networks with limited power and loss. The main idea behind ESMRF is for multicast traffic sources to package their multicast traffic in an ICMPv6 delegation parcel and deliver it to the root of the RPL tree, which advances the multicast traffic bundle in the direction of the initial source. When compared to Trickle Multicast (TM) and SMRF, ESMRF exhibits a promising bundle conveyance proportion and start to finish delay in multi-bounce RPL trees [4]. In multi-bounce forward straight-line geography, where the RPL root is the source of multicast traffic, ESMRF exhibits a similar bundle conveyance proportion and start to finish delay as SMRF while having a low memory overhead. In a retrogressive straight-line geography wherein the most noteworthy position hub is the wellspring of multicast traffic, ESMRF shows comparative execution to its presentation in the forward straight-line geography. For this situation, SMRF thoroughly neglects to convey. It likewise outflanks the TM conspire in the two geographies in general execution. In an irregular geography, ESMRF plainly outflanks both the TM and SMRF plans regarding conveyance proportion and start to finish delay.

3.0 Simulation Environment and Performance Evaluation

In this work, the focus is given to the performance of each protocol based on varying number of nodes and varying the mobile speed of the nodes. The simulations of AMR6, M-CoAP, SARCAST and ESMRF are implemented in Network Simulator-2. The Simulation parameters are described in the Table.2.

3.1 Performance Metrics

The following metrics are used to analyze the performance of multicast routing protocol for IoT applications.

Throughput

The ratio of data packets generated by the source node to those received by the destination node is known as throughput.

$$Throughput = \frac{\sum \text{data packets genrerated by source node}}{\sum \text{data packets received at the destination node}}$$

Reliability

The ratio of successful end-to-end data delivery is used to define reliability.

$$\mathrm{Re}\,liability(r_0, r_1 .....r_{h-1}, r_h) = \exp\left(-\sum_{i=1}^{h} \frac{d^k_{ri-1ri}}{snr_{ri-1ri}} \right)$$

Where $(r_0, r_1 .....r_{h-1}, r_h)$ is route

d^k_{ri-1ri} is distance between the nodes

snr_{ri-1ri} is the transmitted signal-to-noise power

End-to-End Delay

The end-to-end delay is defined as the time that elapses between when a packet is sent and when it is successfully delivered.

End-to-End Delay = End time[i]-Start time[i]

Packet Delivery Ratio

The ratio of the number of packets received and the number of packets expected to be received.

$$PDF = \frac{\sum \text{packets received by the destination node}}{\sum \text{packets sent by the source node}}$$

3.2 Simulation Parameters

The simulation environment is composed of 20 to 80 sensor nodes with a single source and multiple destinations within a 1000m x 1000 m area. The CBR with 512 bytes each data packet makes up the multicast traffic. The setdest tool of ns-2 is used to build the simulation scenarios. There is a 200-second simulation period. The speed of the node is varied from 20 m/sec to 80m/sec.

S.No	**Parameters**	**Particulars**
1.	Simulator	Network Simulator-2
2.	Protocol	AMR6, M-CoAP, SARCAST and ESMRF
3.	No.of nodes	10-100 nodes

4.	Simulation time	200 secs
5.	Simulation area	1000 m X 1000 m
6.	Node movement	Random
7.	Packet size	512 bytes
8.	Sender & Receiver	Sender-1 Recevier-9-99
9.	Pause time	0
10.	Traffic	CBR
11.	Mobility	20 m/s to 80 m/s

Table 2. Simulation environment and parameters

3.3 Simulation Results

In this section, the evaluation of four multicast routing protocols through simulations in NS-2 is provided. Here, each protocol is simulated and analysed by the following two conditions:

a) Varying the number of nodes
b) Varying the traffic load

3.3.1 Varying the number of nodes

The Fig.1 shows the throughput analysis. When increasing the number of nodes, the throughput of AMR6 is higher than others.

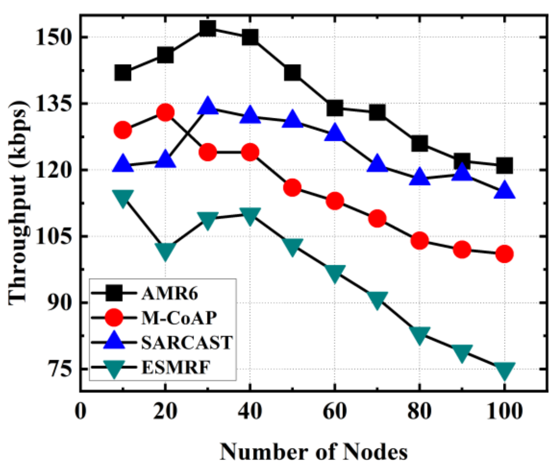

Fig.1 No. of nodes vs Throughput

The Fig.2 shows the reliability analysis. When increasing the number of nodes AMR6 provides better reliability than others.

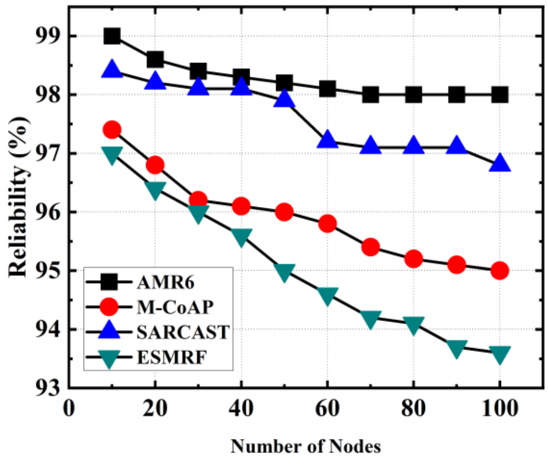

Fig.2 No. of nodes vs Reliabilty

The Fig.3 shows the AMR6 exhibits lesser values of End-to-End delay than others, when increasing the number of nodes.

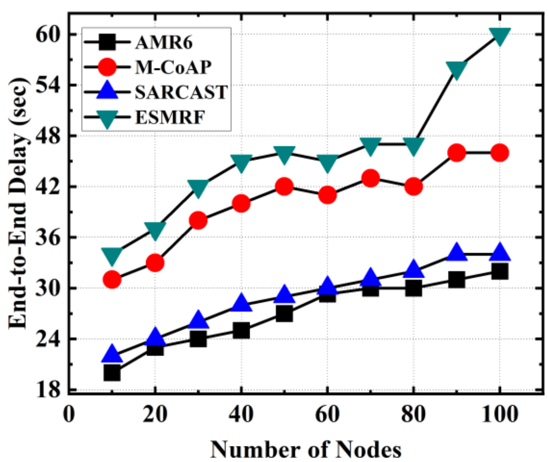

Fig.3 No. of nodes vs End to End delay

Based on the simulation results shown in Fig. 4, the packet delivery fraction of AMR6 is higher than others for varying number of nodes

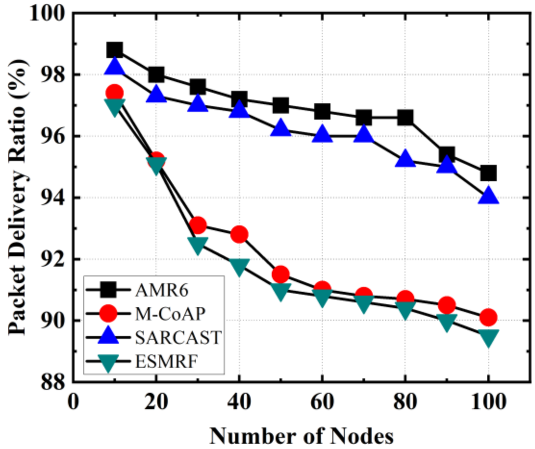

Fig.4 No. of nodes vs Packet Delivery Ratio

3.3.2 Varying the traffic load

Based on the simulation results as shown in the figures Fig.5, Fig.6, Fig.7 and Fig.8, AMR6 provides better throughput, reliability, less delay and better packet delivery fraction as compared to other on varying the traffic load.

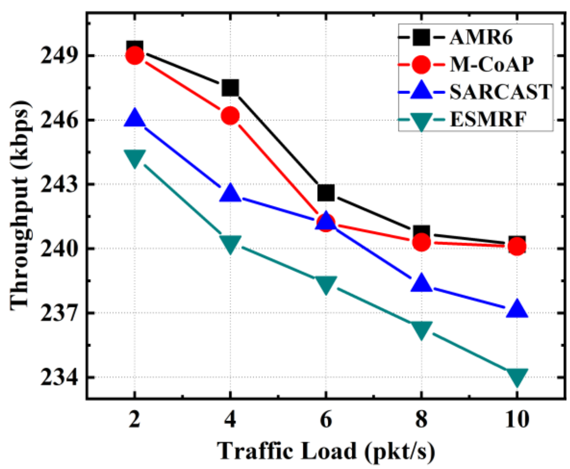

Fig.5 Traffic load (pkts/s) vs Throughput (Kbps)

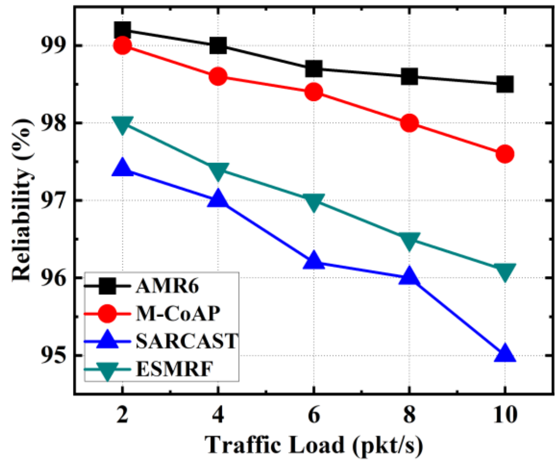

Fig.6 Traffic load (pkts/s) vs Reliability

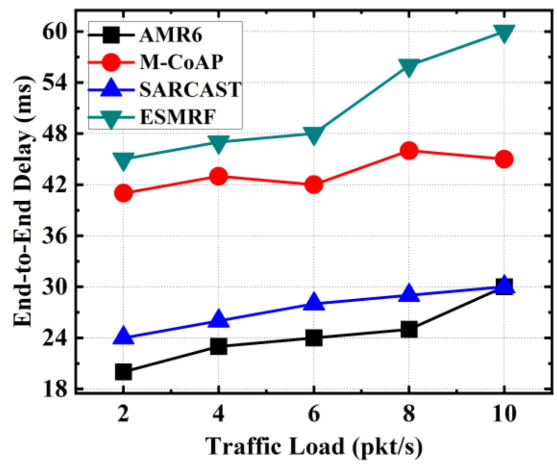

Fig.7 Traffic load (pkts/s) vs End-to-End Delay(sec)

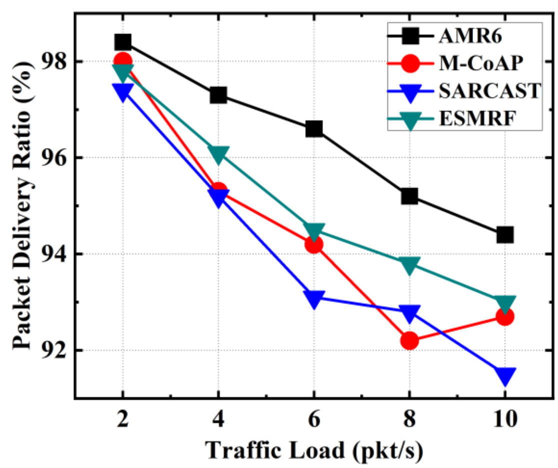

Fig.8 Traffic load (pkts/s) vs PDR(%)

4. Conclusion

The present performance analysis is a comparative performance evaluation for throughput, reliability, less delay and packet delivery fraction of four multicast routing protocol such as AMR6, M-CoAP, SARCAST and ESMRF for IoT. Simulation result shows that AMR6 provides better throughput, reliability, less delay and packet delivery fraction as compared to others. Future work will focus on the integration of high throughput, high reliability and high security techniques on AMR6 for IoT. To achieve high throughput, high reliability and high security on AMR6, it should be tuned and build based on the strengths of existing multicast routing protocols.

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