MOBILITY MANAGEMENT PROTOCOLS IN INTERNET OF THINGS: A CRITIQUE

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Abstract

The Internet of Things (IoT) is an evolving paradigm where the system is inter-connected and inter-related with numerous objects, which can gather and transmit data over a wireless sensor network (WSN) without human intervention. The data transmission is accomplished by IoT based routing protocols. The data packets are transmitted from the source to the destination in the routing process. The proficiency of routing protocol is accomplished by minimizing the path cost. In the context of IoT, the objects and devices are powered by a battery. Hence, protocol routing plays a prominent role in the conservation of energy. The IoT based protocols in WSN and their routing mechanism is detailed in this study. Additionally, the Routing Protocol for Low Power and Lossy Networks (RPL) is discussed in this article, along with the issues.

Keywords: IoT, routing protocol, lossy network, energy-hole, energy conservation and intelligent objects.

I INTRODUCTION

A computer network is a group of computer systems and other computer-related devices connected through any communication medium to converse and share resources. Modern communication technologies highly depend on seamless wireless technology. Communication devices such as laptops, smartphones, personal digital assistants and mobile phones come within wireless technology. Low cost, portability and easy internet connectivity are factors in favour of wireless technology [1].

Wireless networks use radio signals to establish communication instead of Ethernet cable. Wireless networks are classified into two categories: In ad-hoc mode, all the communication devices are connected via a wireless medium, but they do not rely on the base station or access point. An example Ad Hoc Network in Mobile Ad hoc Network. Communication devices are connected via the wireless medium in infrastructure mode and rely on any fixed infrastructure like a base station or access point. All the communication are carried out and controlled by Access points. This type of mode may be part of a wired or wireless network, and it is stated as Basic Service Set (BSS). For instance, Wi-Fi is the best example of this kind of network [2].

In the perspective of the internet of things (IoT), the objects are connected and perceive the environmental information whereas they act accordingly. The data transmission is accomplished by routing protocol, and the transmitted information is processed by computation techniques for further decision making [3]. In Low power and Lossy Networks (LLNs), the router performs with specific limits on memory, energy, processing power and their connections are categorized by instability, minimum data rate, and huge rate of loss [4]. LLNs encompass anything from a limited dozen and up to thousands of LLN routers [5,6,7].

6LoWPAN networks are characterized by low payload size, low data rate, short-range and inadequate resources. Hence 6LoWPAN network protocol defines encapsulation and header compression mechanisms for IPv4 and IPv6 routing of packets within IoT environment. Internet of Things or IoT is a collection of one or many LLNs [8]. This article discusses IoT based routing protocols and their

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significance. The issues and challenges in the routing mechanism also detailed in this study. Based on the issues and challenges, an effective routing mechanism formulation methodology is suggested in this article.

The remainder of the article is organized as follows: the routing protocols in IoT is discussed in Section 2, comparative analysis of routing is given in Section 3, the challenges and issues in the routing protocol are described in Section 4, and the article is concluded with the future suggestion in Section 5.

II INTERNET OF THINGS ROUTING PROTOCOL

Routing is a process that transfers data packets from the source to the destination node. The efficiency of the routing protocol is achieved by reducing path costs. In IoT, the devices are battery-powered. Hence, the routing protocol plays a vital role in energy conservation. The efficient route selection conserves the energy during packet transmission, increasing the network lifetime [9]. It is categorized into three types: route discovery and maintenance, network structure, and operation-based routing protocols.

2.1. Route Discovery and Maintenance Protocols

It provides the route information about the source to the destination node. Generally, the node possesses in either loading or unloading mode. In the storing mode, the participant node collects and transmits the data to its parent. The participant node only transmits the information its parent node in non-storing mode. The route discovery and maintenance protocols are categorized into three types: proactive protocol, reactive protocol, and hybrid protocol [10].

Proactive Routing Protocols

It is most suitable for static networks. It cannot change the topology after the node deployment in the network. Each node maintains its route information in the form of a table format called the routing table. The popular proactive routing protocols are Geographical Energy-Aware Routing (GEAR), Less Energy Adaptive Clustering Hierarchy (LEACH), Open Link State Routing (OLSR) [11] and RPL [12].

Reactive Routing Protocols

In the reactive protocol, a node begins to initiate the route discovery process when the source node wishes to send the information to the destination node. It is most suitable for dynamic networks, and it changes the topology frequently in the network. In IoT, some of the applications use dynamic typologies in their network. The popular reactive protocols are Threshold Sensitive Energy Efficient sensor Network (TEEN), Ad hoc On-Demand Distance Vector (AODV) [13] and Lightweight On-demand Ad hoc Distance-vector Routing Protocol-Next Generation (LOADng) [14].

Hybrid Routing Protocols

It is a form of both proactive and reactive routing protocol. It reduces the latency and control overhead between the participant and the destination node. The popular hybrid routing protocols are Zone Routing Protocol (ZRP) [15] and Temporarily Ordered Routing Algorithm (TORA) [16].

2.2. Network Structure

The routing process is carried out based on the deployment of the network node. The network structure based routing improves the QoS and minimizes the energy consumption in the network nodes. The three types of network structure protocols are hierarchical routing, flat routing and location-based routing.

Flat Routing Protocols

The Flat routing protocol is suitable for the flat structure in large-scale networks. All the nodes perform an equal role, and they collect the data in the network. In an extensive scale network, the routing protocol is difficult to identify the node

uniquely. To solve the addressing issue, the routing protocol introduces a data-centric mechanism. Using this mechanism, the base station sends the request to the neighbour region in queries. The flat routing protocols are directed diffusion, gradient routing, Sensor Protocol Information Via Negotiation (SPIN), Sequential Assignment Routing (SAR), rumour routing, etc [17].

Location-Based Routing Protocols

It determines the position of the sensor node in the networks. The nodes distance is calculated from the node's received signal strength. Neighbour node location is acquired by exchanging data between one node and another node. Alternatively, the sensor location is received through the Global Position System (GPS), satellite, etc. The popular routing protocols are Graphic Adaptive Fidelity (GAF), Greedy Other Adaptive Face Routing (GOAFR) and Most Forward within Radius (MFR) [18].

Hierarchical Routing Protocols

It is a type of network structure routing protocol. The network usually split into clusters. The node with maximum energy acts as a Cluster Head (CH) in each cluster, while the rest of the node acts as a Cluster Member (CM). The CM node forwards the data packets to the CH node. The CH transfers the aggregated data to another CH node or the sink node. It supports the scalability, reduces the data traffic and prolongs the network lifetime. The hierarchical routing can also be divided into two types, namely tree and cluster based routing protocols.

The tree based routing protocols forms the tree structure dynamically in the network [19]. The popular tree-based routing are Weighted Spanning Tree Distributed Optimization (WSDO) and Efficient Tree based Self Organization (ETSO). The cluster-based routing follows the hierarchical structure, which splits the network into several clusters. The drawback of the clustering algorithm requires more initial time to form a cluster in the network. The popular hierarchical routing algorithms are LEACH and advanced multi-hop LEACH [9].

2.3. Protocol Operation

Protocol operation is based on the routing functionalities like communication pattern, delivery method and computation. It is classified into five types, namely query-based routing, multi-path routing, negotiation-based routing, QoS based routing and coherent based routing [9].

Multi-path Routing

Multi-path routing mechanism maintains multiple routes from source to the destination rather than a single route. It avoids data losses during data transmission. For identifying the best route, the source node opts a route with maximum residual energy among several routes in the network. All the nodes are active, and they receive periodic information from the source node. It leads to network traffic and network reliability. The popular multi-path protocols are braided multi-path routing and Reliable Energy-Aware Routing (REAR) [20].

Negotiation based routing

It is a process of eliminating duplicate data through negotiation. Communication decisions are made in the network from the available resource. This protocol has the benefit of reducing energy consumption by removing duplicate information from source to destination. An example of a negotiation routing protocol is the SPIN protocol [21].

QoS based routing

It refers to the network's ability to deliver timely and reliable data. The network resources such as energy, bandwidth and latency also need to be balanced. The popular QoS routing protocols are SAR and Stateless Protocol for End to End Delay (SPEED). SAR is the first QoS routing

protocol, which uses the routing metrics energy, QoS and priority level to select the best parent node for data transfer. The SPEED protocol is one of the QoS routing protocols to avoid congestion among the network nodes [22].

Coherent based routing

The nodes collect the sensor reading from the environment. In each node, data processing is an important task, and it consists of two processes, namely, coherent process and non-coherent process. Incoherent routing, each node performs minimal data processing operations such as duplicate suppression, time sampling and forwarding the information to the CH node. The sensor node transmits the data packets directly to the CH node in non-coherent routing [23].

Query based routing

Each sensor node stores the sensed data locally in the network during query-based routing. It transmits data to the sink node by obtaining the request signal in the form of a query. This process is called directed diffusion. The query-based routing protocols are rumor protocol and Energy Efficient Query-based Routing (EEQR) [24].

III Comprehensive Analysis of IoT based 6LoWPAN Technology

This section discusses the WSN based 6LoWPAN technology that enables sensor devices with internet protocol (IP) to connect with other IP networks without any necessary gateways.

Protocol	Detection of Movement	Architecture of Topology	Address	Buffered data	Deployment of Static Nodes	Mobility Model
Hierarchical Mobile Internet Prtocol version 6 [25]	Routing Solicitation (RS)/ Routing Advertisement (RA)	Star	IPv6	Mobile Anchor Point or Local Agent (LA)	-	-
Mobile IPv6 [26] [11]	RS/RA	Star	IPv6	Home Agent (HA)	-	-
Fast handover for Mobile IPv6 [27]	RS/RA	Star	IPv6	HA	-	-
Proxy Mobile IPv6 [28] [11]	RS/RA	Star	Fixed IPv6	Local Mobility Anchor (LMA)	-	-

Mobility assisted minimum Connected Sensor Cover [29]	-	Tree-mesh that is hybrid	IPv6	Not considered	square zones	To failure node place
Zone routing mobile sensor networks (ZoroMSN) [30]	-	Cluster tree	IPv6	Zone Head	Random nodes	Random walk [44]
Hospital WSN6(1) [31]	Personal area network Identification (PAN-ID)	Star	Fixed IPv6	Not considered	-	Unspecified
Sensor Proxy Mobile IPv6 [32]	RS/RA	Star	Fixed IPv6	SLMA	-	Unspecified
HWSN6(2) [33]	-	Star	Fixed IPv6	Not considered	-	Unspecified
Soft Handover for Moibile WSN6 [34]	RS/RA	Star	IPv6	LMA	-	Markov chain based on Probabilistic Random walk [45]
Inter-Mario [35]	Received Signal Strength Indicator (RSSI) /link quality	Star	IPv6	Foreign Agent (FA)	-	Unspecified
Optimized Link State Routing +MIPv6 [36]	RS/RA	Hybrid: Mesh Star	IPv6	HA	Random	Unspecified

Inter-Personal Area Network (1) [37]	RSSI	Hybrid: Mesh Star-Bus	Out: IPv6	GW	Grid	Marcov chain based on fluid flow
Low mobility (LoWMob) [38]	RSSI	Hybrid: Mesh Star-Bus	In: 16-bit short	PSN	Grid Random in square region	Random waypoint [46]
Inter-Mobility [39]	RSSI /PAN-ID	Hybrid: Mesh Star	Out: IPv6	Intra: NPA Inter: FA	Random	Unspecified
Distributed-LoWMob [38]	RSSI	Hybrid: Mesh Star-Bus	In: 16-bit short	PSN	Grid Random in square region	Fluid flow [47]
Cluster [40]	RSSI	Hybrid: Cluster Tree Star	Hierarchical	P. associated node	Grid	Random walk
Inter-PAN(2) [41]	RSSI	Hybrid: Mesh Star	IEEE 802.15.4	NPSN	Grid	Fluid flow [48]
RPL-Weight [42]	Intended movement	Hybrid: Destination oriented Directed Acyclic Graph Mesh	Out: IPv6 In: 16 - bit short	Sink node	Grid	To estimate the position and place

IV ROUTING PROBLEMS IN IOT PROTOCOLS

IoT networks are resource-constrained networks where the routers and their links are frequently unstable. As a result, the network performance shows low packet delivery ratio and high control traffic overhead [49]. There are many routing problems in RPL based LLNs, such as loop creation, Rank inconsistency, Rank attacks, etc. However, this section focuses on routing problems in RPL due to load imbalance. Load imbalance in RPL is due to greedy parent selection.

Greedy Parent Selection

A node is considered greedy if it moves closer to the root by projecting a lower Rank for DODAG construction. This greedy attempt is a way to disturb the network or improve some other routing metric. Therefore, once a node has joined DODAG Version, RPL disallows greediness to prevent instabilities in the DODAG version [50].

Network Instability

The load imbalance in the RPL network generates instability in the network. Due to frequent parent switching, DODAG Version increases, and the communication overhead raises greatly for frequent construction and maintenance of the network. This gives rise to poor network performance [51].

Energy Hole

Load imbalance not only brings poor network

performance but also adds more network load on router nodes. The router nodes spend much of their energy in forwarding control and data packets. Thus energy hole scenario occurs. Frequent construction of network topology depletes the energy of the router nodes. The network can be disrupted further if router nodes face early node death [52].

Bottleneck

When the energy hole problem occurs to the router node, which is one hop to the root, this is called bottleneck or hotspot. Since nodes in RPL network use multi-hop for data delivery, these nodes are busy all the time either sending their data to the sink or forwarding data from their child nodes in the network. Since all nodes in the network go through these nodes, the extra load gets concentrated with the nodes closer to the root. In a bottleneck, the nodes and links attached to these nodes disconnect from the DODAG and partitioning of the network takes place [53].

Network Life Time

The routers in RPL network use Radio Duty Cycle (RDC) mechanism to save energy. Nevertheless, load imbalance problems in RPL network results in a concentration of more load on the routers. The instability of the network also adds more load on the router nodes. This results in shortened network lifetime [54].

Poor Packet Delivery Ratio

Data delivery from the sender to the sink is very important. The load imbalance and network instability generate huge control messages that the possibility of packet loss is high. Due to increased load and bottleneck problems, the routers fail to forward the packets. This results in a poor packet delivery ratio [55].

Control Traffic Overhead

The load imbalance problem in RPL, such as greedy parent selection, thundering herd, parent switching and network instability, generates large number of control traffic overhead. Frequent generation of DODAG Version, local repair involves DODAG construction too frequently. Hence load balancing brings huge control traffic overhead [56].

V CONCLUSION

Wireless communication has made travel more comfortable, business on the move and data sharing easier. Therefore wireless technology is as easy as people sitting in conference hall can access internet and share information easily by connecting to a wireless router. Wireless technology made the IoT possible whereas objects can gather and transmit data over a wireless sensor network (WSN) without human assistance. IoT based routing protocols attain the data propagation. Due to the vast amount of data and schema less environment has made numerous issues in the network namely energy hole, network performance, packet drop etc. The issues are effectively handled by the effective routing mechanism with the meta-heuristic technique. In the future, IoT protocols will be enhanced by the clustering, aggregation and routing mechanism.

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