

A ROUTING ALGORITHM USING THE GATEWAY LOCATION VIA BROADCASTING THE HELLO PACKET IN A HYBRID WIRELESS MESH NETWORK

THUẬT TOÁN ĐỊNH TUYẾN SỬ DỤNG VỊ TRÍ GATEWAY QUA QUẢNG BÁ GÓI TIN HELLO TRONG MẠNG HÌNH LƯỚI KHÔNG DÂY LẠI

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Ngày nhận bài: 23/09/2020, Ngày chấp nhận đăng: 16/03/2021, Phản biện: TS. Ngô Hải Anh

Abstract:

In a hybrid wireless mesh network (HWMN), traffic is mainly concentrated to and from the gateways due to the need for mobile devices to exploit services on the Internet. Therefore, routing algorithms in the HWMN network requires consideration of this traffic characteristic. In this paper, we have proposed a routing protocol based on the gateway location via hello messages to limit the broadcast area of the routing request in the HWMN network. The simulation results show the efficiency of the proposed protocol through the analysis of routing overhead and network throughput.

Keywords:

HWMN, AODV, routing, gateway, ad-hoc.

Tóm tắt:

Trong mạng hình lưới không dây lại (HWMN), lưu lượng chủ yếu tập trung đi và đến các gateway do nhu cầu của các thiết bị di động là khai thác các dịch vụ trên Internet. Do đó, việc xác định tuyến trong mạng HWMN đòi hỏi phải chú ý đến đặc tính lưu lượng này. Trong bài báo này, chúng tôi đã đề xuất một giao thức định tuyến dựa trên vị trí gateway nhờ các thông báo hello nhằm hạn chế vùng quảng bá của yêu cầu định tuyến trong mạng HWMN. Kết quả mô phỏng cho thấy hiệu quả của giao thức đề xuất qua phân tích dư thừa các gói tin định tuyến và thông lượng mạng.

Từ khóa:

HWMN, AODV, routing, gateway, ad-hoc

1. INTRODUCTION

A Hybrid Wireless Network (HWMN) is the most generic type of Wireless Mesh Networks [1, 2]. As shown in Fig 1, a HWMN consists of static mesh routers that form the backbone of the network (level 2). Some mesh routers can include gateway functionality (IGW) and provide

connectivity to other networks, such as the Internet and other networks (level 1). Besides, mobile clients can act as a dynamic extension of the static infrastructure part of the network, by implementing routing and packet forwarding functionalities (level 3). The hybrid mesh architecture is the most applicable because mesh clients can not

only directly communicate with other mesh clients, but also access the Internet service through mesh routers. In this paper, we focus on this architecture, especially on mesh clients accessing Internet service through gateway nodes (see Fig. 1).

Although hybrid wireless mesh networks are a particular type of mobile ad hoc network (MANET) [2, 3], there are also significant differences between hybrid wireless mesh networks and general MANETs. In hybrid wireless mesh networks, the mesh routers are relatively powerful and static nodes, which have access to a power mains system or are equipped with high capacity batteries. Mesh routers are typically equipped with multiple radio interfaces assigned to non-overlapping channels, thereby significantly increasing the transmission capacity of wireless mesh networks [4]. In contrast to the mesh routers, the mesh clients are relatively constrained mobile client devices, such as a smartphone, laptop, or PDA, with just a single radio, high mobility, and limited battery power. Furthermore, in hybrid wireless mesh networks, most of the traffic is directed to/from a gateway, as the mesh clients generally access services on the Internet or other networks. Consequently, an efficient routing strategy needs to take into account the traffic pattern in hybrid wireless mesh networks. Accordingly, this paper proposes an improvement of AODV routing protocol based on gateway discovery using HELLO packet and restricting the broadcast area of route requests to reduce routing overhead in

HWMN.

The remainder of the paper is organized as follows: Section 2 discusses relevant related works. The proposed protocol is described in Section 3. Section 4 provides details of the simulation environment and simulation results. Some conclusions are given in Section 5.

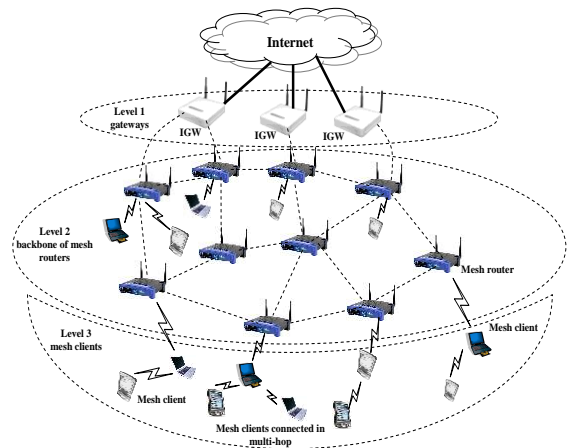


Fig. 1. A Hybrid Wireless Network (HWMN)

2. RELATED WORKS

Many routing protocols have already been proposed for ad hoc networks and can be applied for HWMN. They generally can be categorized as reactive [5, 6] or proactive [7] based on the time of the route availability to the source node when a node has a data packet to send. In proactive routing protocols, the source node knows the route before it has any data packets to send. Routes to the destination nodes are semi-permanently maintained in a routing table based on the periodic exchange of routing tables between neighboring nodes. Destination Sequence Distance Vector (DSDV) [7] is commonly used as a proactive routing protocol. In reactive routing protocols, the

routes are established on-demand. When the source node has data to send, it initiates a route discovery procedure, and once the node acquires the desired routing information from the route discovery procedure, it forwards the data using the acquired route. Dynamic Source Routing (DSR) [5] and Ad-hoc On-demand Distance Vector (AODV) [6] are examples of reactive routing protocols. In AODV [6], when a source node intends to communicate with a destination node whose route is unknown, it broadcasts a Route Request (RREQ) packet. Each RREQ contains an ID, source address, destination address, sequence number together with a hop count and control flags. If the RREQ recipients have not seen the source address and RREQ ID pair or do not have a fresher (with a higher sequence number) route to the destination, they rebroadcast the same packet after incrementing the hop-count. Intermediate nodes also create and preserve a Reverse Route to the source node for a certain interval of time. When the RREQ reaches the destination node or any node that has a fresh route to the destination, a Route Reply (RREP) packet is generated and unicast back to the source of the RREQ. Each RREP contains the destination sequence number, source and destination node addresses, route lifetime, and hop count and control flags. Each intermediary node that receives the RREP then increments the hop-count, establishes a Forward Route to the source of the packet, and transmits the packet via the Reverse Route. To preserve the connectivity information, each node

executing the AODV can use link layer feedback or periodic HELLO packets to detect link breakages with nodes that it considers as its immediate neighbors. When a link break is detected for a next hop of an active route, a Route Error (RERR) packet is sent to the active neighbors using that particular route. The proactive and reactive approaches have already been merged in hybrid routing protocols that aim to combine the advantages of both approaches. For example, the Zone Routing Protocol (ZRP) [8] is a hybrid routing protocol based on the notion of a zone, where a proactive protocol is used among the nodes of a particular zone, while a reactive protocol is used to reach a node outside that zone. However, this routing protocol was designed for homogeneous ad hoc networks, and is unable to differentiate between the different types of node in hybrid wireless mesh networks.

Ad hoc routing protocols are promising candidates for hybrid wireless mesh networks, due to their capability to deal with dynamic environments. However, the direct application of routing techniques for ad hoc networks to hybrid wireless mesh networks results in inferior performance, as the characteristics of mesh networks are not utilized. In hybrid wireless mesh networks, most of the traffic is directed towards a gateway and thus all the source nodes require a route to a gateway node for data delivery beyond the mesh. Reactive routing protocols [5, 6] generate multiple requests towards a gateway, they increase the traffic and

overhead near the gateway. Moreover, in the case of a large network, the time required to acquire a route towards a gateway becomes significant, thereby increasing the overall delay. Conversely, in the case of proactive routing protocols [7], each node periodically sends updates of its routing table to maintain correct route information to all destinations, which results in a large overhead. In particular, the high mobility of the mesh clients degrades the performance of proactive routing, as the routing table becomes quickly outdated and requires an enormous overhead to keep it up to date. In addition, since ad hoc routing protocols were originally designed for homogeneous ad hoc networks, consisting of resource-constrained mobile devices, their performance is not optimal in hybrid wireless mesh networks, as they are unable to take full advantage of the mesh routers in hybrid wireless mesh networks.

3. PROPOSED ROUTING PROTOCOL FOR HYBRID WIRELESS MESH NETWORKS

As mentioned in the previous section, the large amount of overhead needed in broadcasting RREQ messages is the main drawback of the AODV in high load networks such as HWMN. The overhead mostly consists of route request messages. In the route discovery process, each intermediate node can broadcast packets to all neighbors whereas most traffic is destined from mesh clients to the gateway in HWMN. These increase the number of redundant messages transmitted in the network and reduce the network

performance.

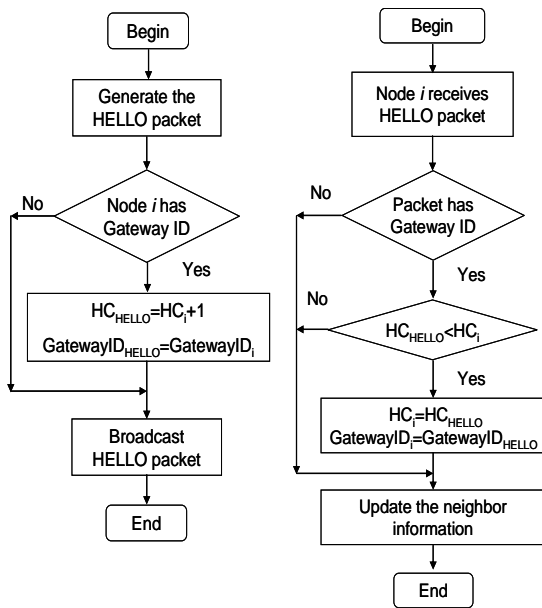
In this section, we introduce IMP-AODV routing protocol for HWMN, which is an improvement of AODV routing protocol based on gateway discovery using hello packet and restricting the broadcast area of route requests to reduce routing overhead in HWMN.

3.1. Gateway discovery

The AODV uses periodical HELLO messages to indicate the presence of a mesh node to its neighbors. We utilized it for gateway discovery without any protocol overhead. HELLO message is modified with I-flag to indicate that these packets were originated by a gateway [9,10]. It also contains the gateway's address and the distance value of the broadcasted mesh node.

Each mesh node maintains a distance value (HC) to indicate the distance (number of hops) to a gateway, which is initially set to be infinite. Only a gateway's HC value is set to 0. Mesh nodes periodically send HELLO message to update neighbor information, meanwhile, gateway node broadcasts HELLO with gateway information (I-Flag) and distance value (HC+1) (Fig. 2a). When mesh nodes within one-hop away from the gateway receive a HELLO message with I-flag and smaller distance value (HC_{HELLO}), they update gateway information and set their HC value with the HC value in the HELLO message. Mesh nodes later broadcast their HELLO message with I-flag and their new HC

value (Fig 2b). Thereafter, the two-hop away nodes receive these HELLO packets, thus they learn that they are two-hop away from the gateway. In this manner, every node discovers the gateway's information and learns their distance (HC) to the gateway. Imp-AODV also used sequence number in HELLO packet to determine the timeliness of each packet.



(a) Sending Hello with I-Flag

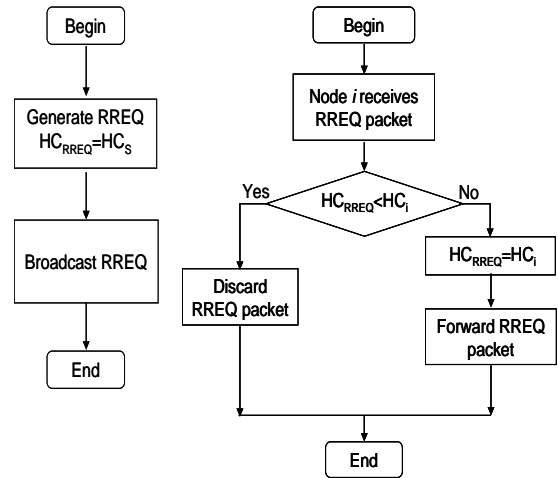
(b) Receiving Hello with I-Flag

Fig. 2. Gateway discovery algorithm

3.2. Route discovery

The route discovery in IMP-AODV is fundamentally similar with AODV. It only improves RREQ forwarding process such that reduces the scope of broadcasting to the gateway. IMP-AODV protocol adds distance value (HC field) to the Route Request (RREQ) message to indicate the distance to the gateway.

When mesh node desires a route to a gateway for which it does not have a route, it broadcasts the RREQ with an HC set to its HC value as shown in Fig. 3(a). When a mesh node receives a RREQ message with a smaller distance value (HC), it discards RREQ message. Otherwise, it replaces the HC value on the RREQ with its HC value and then re-broadcasts the RREQ to all neighbors in the same manner in AODV (Fig. 3b).



(a) Source mesh node; (b) Intermediate mesh nodes

Fig 3. Route Request Forwarding

When a mesh node receives the RREQ, it establishes a reverse route to the RREQ source in its routing table, and it either replies to the RREQ if it has an entry for the gateway or it forwards the RREQ. Finally, the RREQ reaches the gateway and it unicasts a RREP. The node receiving a RREP sets up a forward route to the gateway and desirable routes can be discovered.

Route maintenance is similar to that of the AODV. An existing routing entry may be

invalidated if it is not used within a specified time interval, or if the next hop node is no longer reachable. In these cases, an invalidation notice is propagated to the neighbors that have used this node as the next hop. Each time a route is used to forward a data packet, its route expiration time is updated. When a node detects that a route to a neighbor is no longer valid, it removes the invalid entry and sends a route error message to the neighbors that are using the route. Nodes that receive error messages will repeat this process. Finally, the source requests a new route if one is still needed to that destination.

4. PERFORMANCE EVALUATION

4.1. Simulation parameters

To evaluate the performance of the proposed routing protocol, simulations were performed using the NS-2 network simulator [11,12]. A hybrid wireless mesh network with 99 mesh nodes and 01 gateway deployed on an area of 2000m x 2000m. We evaluated for 02 topologies: grid and random. For the grid topology, nodes are distributed 200 m apart. For the random topology, we generated using setdest program in NS2.

Table 1.Simulation Parameters

Routing Protocol	AODV vs. IMP-AODV
Simulation time	250 seconds
Simulation Area	2000 × 2000 m ²
Transmission range	250 m

Number of flows	10, 20, 30, 40, 50, 60, 70, 80
Traffic type	CBR (UDP)
Packet size	512 bytes
Number of mesh nodes	99
Number of gateways	01
Topology	Random, Grid

4.2. Simulation results

To evaluate the efficiency of the IMP-AODV routing protocol, the network performance parameters used for evaluation including throughput and relative routing overhead.

- *Throughput*: This is defined as the amount of data that is transmitted through the network per unit time, (i.e., data bytes delivered to their destinations per second).
- *Relative routing overhead*: The ratio of the number of routing control packets over the number of delivered data packet.

Figures 4 and 5 compared the relative routing overhead between AODV and IMP-AODV protocols for a random and grid topologies. The relative routing overhead between two routing protocols becomes to be more distinct as the number of flows increases from 10 to 80 in HWMN. Under the heavy load, IMP-AODV can significantly reduce the routing overhead (by about 54% at 80 flows in grid topology) for traffic destined to the gateway. This improvement is due to the IMP-AODV protocol restricting the broadcast area of route request to reduce routing overhead in HWMN.

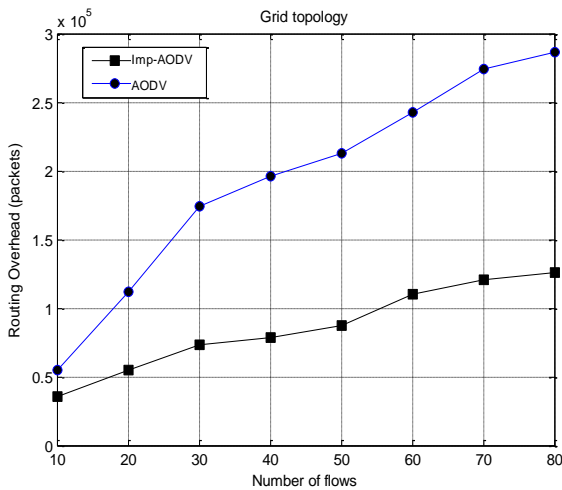


Fig 4. Relative routing overhead vs. the number of flows in grid topology

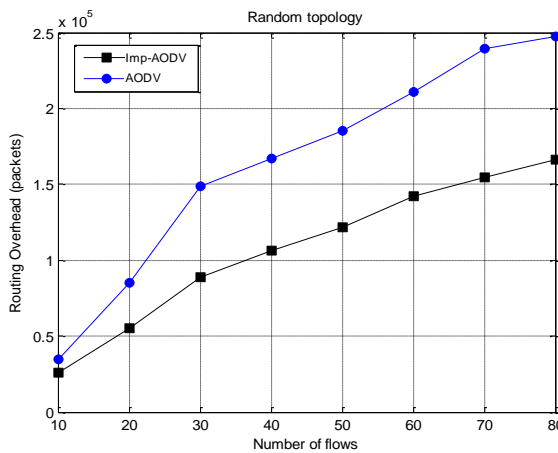


Fig 5. Relative routing overhead vs. the number of flows in random the number of flows in random

Figures 6 and 7 showed the comparison results of data transmission efficiency (throughput) of protocols IMP-AODV and AODV by increasing the number of flows. These figures show that at lower traffic load, the throughput of two routing protocols is similar, but as the number of flows increases, the total throughput of IMP-AODV outperforms AODV significantly. Under heavy load (at 70

flows), compared with AODV, we note that IMP-AODV can improve the throughput by 20% for grid topology. This throughput enhancement of IMP-AODV is due to the significant reduction of bandwidth wasted by route request messages in the route discovery.

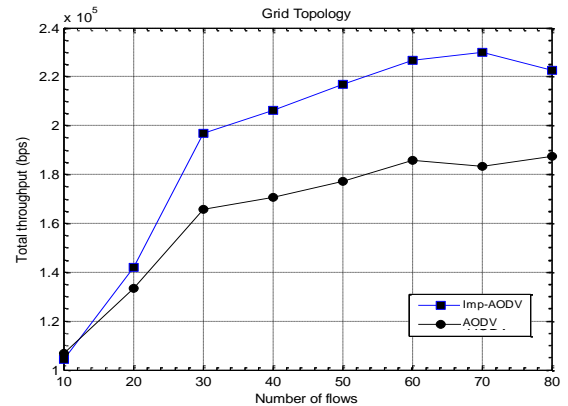


Fig 6. Total throughput vs. the number of flows in grid topology

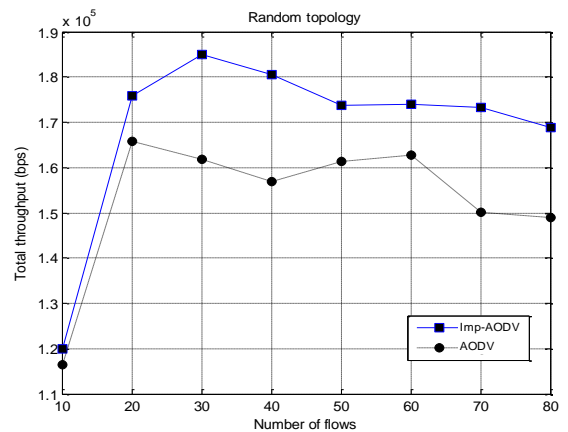


Fig 7. Total throughput vs. the number of flows in random topology

5. CONCLUSIONS

In this paper, we proposed IMP-AODV routing protocol which based on gateway discovery using hello packet and restricting the broadcast area of route

request to reduce routing overhead in HWMN. We evaluated the network performance of IMP-AODV and AODV through packet-level simulation using the

NS-2. Simulation results showed that IMP-AODV could significantly reduce routing overhead and enhance overall throughput performance.

TÀI LIỆU THAM KHẢO

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Giới thiệu tác giả:



Tác giả Lê Anh Ngọc tốt nghiệp đại học ngành toán và tin học tại Trường Đại học Vinh và Trường Đại học Khoa học tự nhiên - Đại học Quốc gia Hà Nội các năm 1996 và 1998. Năm 2001 nhận bằng Thạc sĩ ngành công nghệ thông tin tại Trường Đại học Bách khoa Hà Nội và năm 2009 nhận bằng Tiến sĩ ngành kỹ thuật thông tin và truyền thông tại Đại học Quốc gia Kyungpook – Hàn Quốc. Hiện nay tác giả đang công tác tại Trường Đại học Điện lực.

Lĩnh vực nghiên cứu: hệ thống thời gian thực, mạng truyền thông, Internet of Things, tính toán thông minh.

