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**Annotation.** BATMAN-ADV is a wireless routing protocol operating at the data link layer of the OSI model. It transmits routing information using Ethernet frames and utilizes MAC addresses for node identification. With the ability to run multiple protocols at the network layer, BATMAN-ADV offers flexibility and scalability. By functioning as a Linux kernel module, it minimizes CPU overhead and energy consumption. This makes it a favorable choice for energy-sensitive MANNET systems.

**Keywords:** BATMAN-ADV, Wireless routing protocol, MANNET

**Introduction.** BATMAN-ADV (Better Approach to Mobile Ad-Hoc Networking Advanced) is a new wireless routing protocol. The protocol runs on the data link layer of OSI model in the form of Linux kernel module, and transmits routing information through Ethernet frame. Each node is identified by MAC address instead of IP address for communication. The network layer is free to run a variety of protocols, with better flexibility and scalability.

Most wireless routing protocols run on Layer 3 of the model. They send packets, exchange routing information, and process the kernel's routing table to implement routing policies. BATMAN-ADV operates entirely at the second layer of the model, transmitting routing information through Ethernet, and the protocol also handles data traffic. The protocol encapsulates and forwards all data until it reaches its destination, simulating a virtual network exchange environment [1]. As a result, all nodes act as if they are in a local link; they are not aware of the topology of the network and are not affected by changes in the network.

The BATMAN-ADV routing protocol is essentially an integrated module of the Linux kernel, and data is processed in the kernel space, which greatly reduces the overhead of system CPU resources and correspondingly reduces energy consumption. The vehicle node of the tactical MANNET system is very sensitive to the weight, volume and energy consumption of the electronic equipment, so the choice of this protocol is very advantageous.

**Packet classification.** The BATMAN-ADV protocol has eight packet formats.

**BATADV\_IV\_OGM:** OriginatorMessage (Source node message) is used to discover nodes in the wireless environment and establish routing information. At the same time, the protocol determines the metric value based on the number of legitimate messages received. This is the most important packet format, its main functions are: to the whole network other nodes to show their own existence; The route measurement is carried out by counting the received OGM messages [2]. The corresponding route is established through OGM messages.

**BATADV\_BCAST:** Packet with broadcast payload, which is broadcast information to all nodes, since it is implemented at the data link layer, sent to nodes in the same conflict domain;

**BATADV\_CODED:** This is a network coded packet. It uses network coding technology to combine two packets into one transmission process to reduce the total transmission time.

**BATADV\_UNICAST:** A packet with a unicast payload, which is sent to a single node with a MAC address as its ID;

**BATADV\_UNICAST\_FRAG:** If the length of the - packet exceeds the value of the link, the

packet needs to be fragmented. In this packet, in addition to the payload, there is also fragmentation information;

BATADV\_UNICAST\_4ADDR: unicast packet that contains the source address of the sender in addition to the payload;

BATADV\_ICMP: Similar to ICMP in the IP protocol, the ping or traceroute command can be used at the data link layer (the return message is a MAC address).

**BATMAN-ADV route discovery mechanism.** The main function of the BATMAN-ADV routing protocol is to find the appropriate next hop for a given destination node. In other words, for a node running the BATMAN-ADV routing protocol in the network [3], it needs to maintain information about all reachable nodes in the whole network, and for each reachable node, it needs to maintain information about all neighboring nodes that can reach the node. Transmission Quality (TQ) is use for measures the transmission quality of the path (Link quality). The neighbor node with the highest TQ is the next hop of the route.

The BATMAN-ADV routing protocol runs in the following parts:

(1) Each node broadcasts an OGM (Original Message) message;

(2) When a node receives an OGM message from another node, it forwards it according to the policy so that the OGM message can be spread to the whole network. Therefore, according to the source node of the detection packet, all the nodes that can be reached in the whole network can be known, and the relevant information of these nodes can be maintained, and the path of all the reachable nodes can be obtained.

(3) In a wireless multi-hop network, there may be multiple reachable paths for a given destination node. Therefore, for each reachable node, maintain a list of local neighbors that are reachable to the node, and perform appropriate routing metrics on each path to select the best path for routing.

**Operation mechanism.** For the node running the BATMAN-ADV routing protocol, it will periodically broadcast OGM packets [1]. Its main functions are: (1) to show its existence to other nodes in the whole network; (2) Route measurement is carried out by statistics of legitimate OGM messages received; (3) Establish the corresponding route through OGM messages.

The format of the OGM frame is shown in Figure 1.

Type	version	Survival time	Flag
Serial number			
Source node mac address (first four bytes)			
Last two bytes of the mac address of the source node		Last two bytes of the mac address of the previous hop	
Last-hop mac address (last four bytes)			
Reserved field	TQ	TVLV length	

Fig. 1. OGM frame format

Type is the type that distinguishes packets. Version is the version number of the protocol. The serial number is used to identify whether the same OGM packet is received from multiple places. Time To Live (TTL) is the maximum number of forward hops before they are discarded [5].

After receiving OGM packets from other nodes, each node broadcasts the OGM packets to the outside through the corresponding forwarding mechanism, so that the OGM messages sent by one node

can flood to all nodes in the whole network. To reduce the overhead of message flooding, each node receives the same OGM packet only once.

After receiving an OGM packet from an interface, a node processes the packet, including determining whether the packet is valid and determining the relationship between the local node and the source node. Each time a node receives an OGM packet, it updates the information in the routing table. The main contents of the update are: (1) The link quality between the local node and the one-hop neighbor; (2) List of source nodes reachable by local nodes; (3) For each source node, the next hop neighbor node quality of all reachable paths; (4) Information about local network interfaces that reach all neighboring nodes (figure 2).

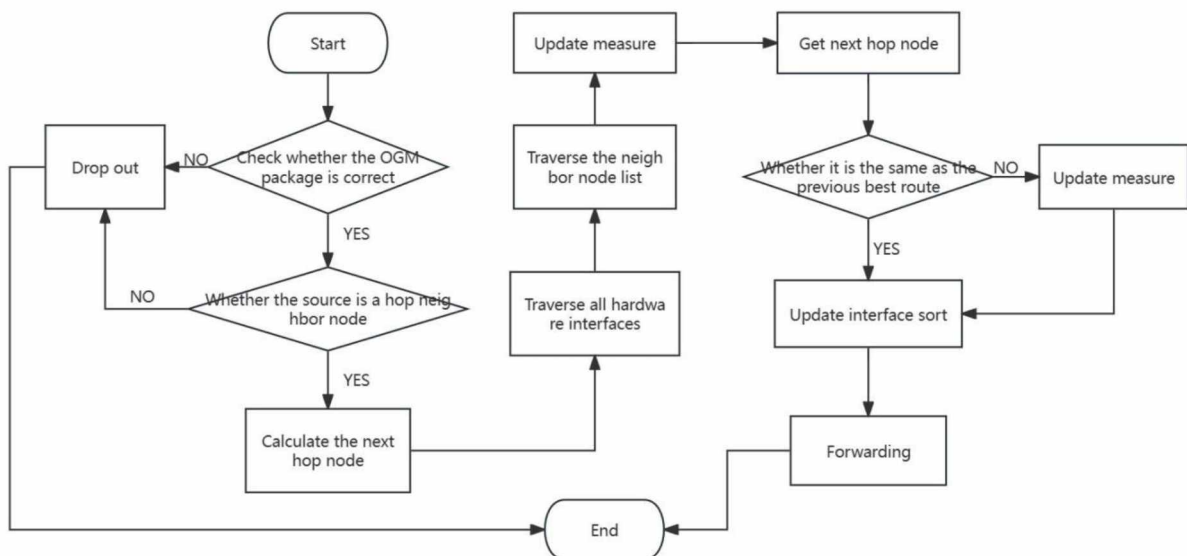


Fig. 2. Operation when a node receives an OGM packet

**Application of BATMAN-ADV protocol in wireless AD hoc network.** Discovering the AD hoc topology: BATMAN-ADV collects and exchanges neighbor information of nodes to automatically build and maintain the AD hoc topology [6]. Nodes can join or leave the network dynamically without manually configuring routing information. This makes the deployment and management of AD hoc networks easier and more flexible.

**Multipathing and load balancing:** BATMAN-ADV supports multipath routing, that is, packets can be transmitted to their destination through multiple different paths. This improves the reliability and fault tolerance of the network, and enables load balancing, making the transmission of data across the network more efficient.

**Network extensibility:** BATMAN-ADV allows nodes in the network to join and leave freely without complex configuration or management. This allows the scale of the network to be flexibly scaled according to demand, suitable for a variety of scenarios, such as mobile sensor networks in cities, emergency communications at disaster sites, etc.

**Low power consumption:** The BATMAN-ADV protocol is designed with energy efficiency in mind, reducing the CPU overhead and energy consumption of the system through data processing and transmission in the kernel space. This is particularly important for mobile devices and sensor nodes in wireless AD hoc networks, extending their battery life and improving the sustainability of the system.

**Conclusion.** The application of BATMAN-ADV in wireless AD hoc networking makes network deployment more simple, more scalable, with multipath and load balancing capabilities, and can reduce energy consumption, and is suitable for a variety of mobile and dynamic network environments.

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## BATMAN-ADV: ЭНЕРГОЭФФЕКТИВНЫЙ ПРОТОКОЛ БЕСПРОВОДНОЙ МАРШРУТИЗАЦИИ ДЛЯ ДИНАМИЧЕСКИХ ОДНОРАНГОВЫХ СЕТЕЙ

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**Аннотация.** BATMAN-ADV – протокол беспроводной маршрутизации, работающий на канальном уровне модели OSI. Он передает информацию о маршрутизации с помощью кадров Ethernet и использует MAC-адреса для идентификации узла. Благодаря возможности запуска нескольких протоколов на сетевом уровне BATMAN-ADV обеспечивает гибкость и масштабируемость. Функционируя как модуль ядра Linux, он минимизирует нагрузку на процессор и потребление энергии. Это делает его выгодным выбором для энергочувствительных систем MANNET.

**Ключевые слова:** BATMAN-ADV, протокол беспроводной маршрутизации, MANNET