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Optimized utilization of Proactive Routing Protocol in Tactical MANET scenario

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Abstract:

Mobile Ad Hoc Network (MANET) comprises of wireless communication nodes that are disseminated arbitrarily and form dynamic topology for communication. Routing protocols play a key role in determining the optimal route between source to destination and forwarding the packet from source to destination for out-of-range packet disseminations. In MANET the choice of routing protocol is important due to the movability of the nodes because the routing protocols can highly impact the performance of MANET. In MANET routing has to cater for parameters like minimum route acquisition latency, low overhead, limited bandwidth and support for multiple services. This paper highlights the optimized utilization of the dynamic proactive routing protocol OLSR (Optimized Link State Routing) v2 to meet the QoS (Quality of Service) requirements in a tactical communication scenario. OLSR v2 uses MPR (Multi Point Relay) for transmitting unicast data, broadcast data and PTT as well as IP based voice for meeting their latency requirements. This paper also analyses how cross layer optimizations can be done to reduce the control overhead in wireless MANET routing.

Keywords—MPR, MANET, OLSR, Ad hoc Networks, Routing Protocols

1.INTRODUCTION

Ad-hoc network consists of wireless nodes which can be deployed easily with minimum overhead. This feature makes them suitable for scenarios where there is no existing infrastructure and users have to share the information. The use of wireless nodes has become prevalent now a days due to advancement in technology. Wireless nodes are spread in a large area due to mobility and thus the range of the radio nodes increases. To achieve communication between these out-of-range nodes, there is a requirement of intermediate nodes which can act as a relay node and also routing protocols to choose the best route between source and destination nodes. Selection of a routing protocol with mobile nodes is more different and complicated than those for wired networks having immobile nodes. Major challenges in mobile ad hoc networks are limited bandwidth and frequent topological changes. The selection of routing protocol has to meet the parameters like minimum route acquisition latency, limited bandwidth and also it has to minimize the control traffic overhead. It should also be capable of handling link failures due to mobility in the network. To reduce the control overhead in network, optimization is required at the routing protocol as well at the layers viz network and MAC. This paper focusses on the optimized utilization of OLSR V2 protocol to meet the QoS in MANET scenario.

2.MANET ROUTING PROTOCOLS

The objective of routing protocols is to find the best, efficient and reliable route between communicating nodes in a network. Relaying packets to the next hop and decision-making for relaying the packets are the primary means for route determination. Routing is crucial and challenging in the MANET as the network architecture and connectivity is agile and volatile due to mobility among the nodes. Primarily routing protocol types consists of Proactive,

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Reactive and Hybrid Protocols [1]. In a MANET environment arrival/departure of the nodes is a key factor for any routing protocol. Another key consideration is to keep routing table size minimal. For effective bandwidth utilization the size of route selection protocol has to be minimum as it can affect the control packet transmitted across the network. Routing protocols are grouped on the idea of in what way and at what time the routes are determined, and involves selection of the shortest route to the destination. Figure 1 shows the categorization of various Routing protocols.

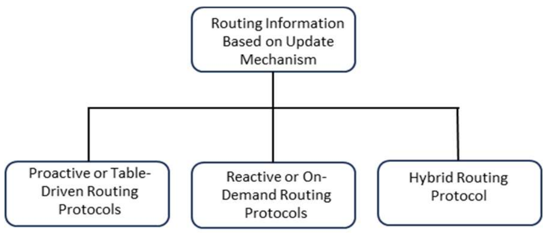


Figure 1: Categorization of Routing Protocols

Reactive (On-demand) Routing Protocols

On-demand routing protocols starts there functioning only when the source node has some data to transmit [2]. These protocols disseminate discovery and maintenance messages in the network for determining the path from source node to destination. These protocols suit the networks where topology changes frequently.

Proactive (Table Driven) Protocols

This category of routing protocols involves continuous upkeeping of a table to update the routing information. These protocols continuously exchange messages to update topological information regarding the network [3]. Any change in the topology is reflected in the tables due to periodic dissemination of protocol messages.

Hybrid Protocols

This class of routing protocols incorporate the prime attributes of above two specified types. These protocols are adjustable in nature and adjusts according to the area and location of the source and destination mobile nodes. These protocols divide the nodes into different routing zones. Within a zone suitable proactive class of protocol is used whereas outside of zone on-demand approach is used. This is because most of the time node communicates with other nodes within the zone only.

Table 1 shows common routing protocols.

Routing Protocol Type	Some Common Routing Protocols
Reactive	Dynamic source routing (DSR), Adhoc on-demand distance-vector routing (AODV)
Proactive	Destination sequenced distance-vector (DSDV), Wireless routing protocol (WRP), Optimized link state routing (OLSR)
Hybrid	Zone routing protocol (ZRP)

Table 1. Common Routing Protocols

OLSRv2

The Optimized Link State Routing Protocol (OLSR) [4] is evolved for MANET. It performs as a table driven, proactive protocol. This protocol is stable as it is based on link state routing. It provides instantaneous routes when needed due to its proactive category. It operates as table driven by sharing topology information with other nodes of the network frequently. It is tailored to work in a completely distributed fashion and does not rely on any central entity. The Optimized Link State Routing Protocol version 2 (OLSRv2) augments the OLSR (version 1). OLSRv2 retains the same fundamental procedures and processes, upgraded by the ability to use a link measure other than hop count in choosing of the paths. Minimization of the messages being exchanged by omitting HNA (Host to Network Attachment) and MID (Multiple Interface Declaration) messages is done. The main idea here is that of multipoint relays (MPRs) [5]. Each router computes sets for "flooding MPRs" and "routing MPRs" ,these sets are being used for flooding and topology minimization.

OLSR v2 Architecture

Figure 2 shows the architecture of OLSR v2 protocol with 2 nodes.

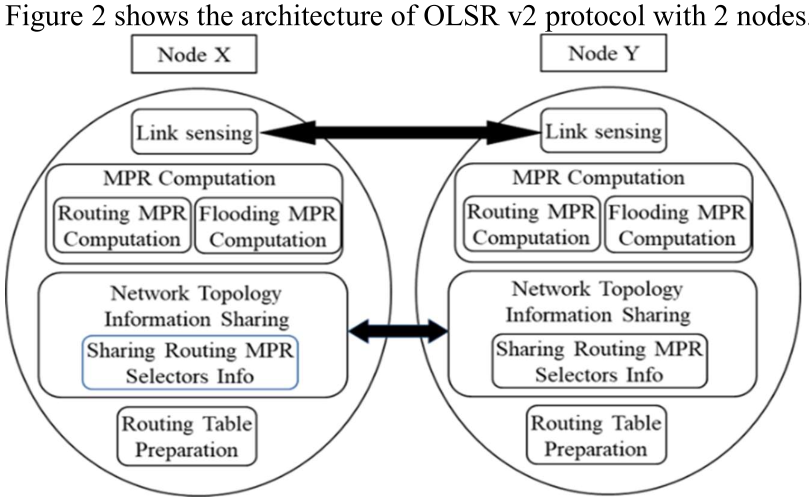
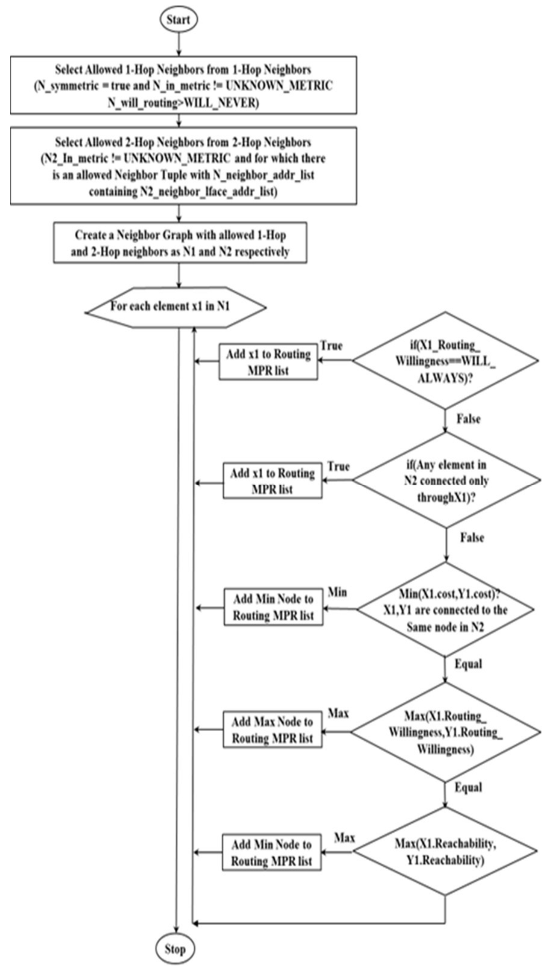


Figure 2: OLSR v2 Architecture

This architecture explains the following components:

i. **Link Sensing**: It is the process of finding 1-Hop and 2-Hop neighbors. Link sensing is done by periodic exchange of hello messages [6].

ii. **MPR Computation:** There are two types of MPRs in OLSRv2 Protocol. They are Routing and Flooding MPRs. Routing MPRs reduce the generation of the TC messages. Flooding MPRs are used for flooding reduction (flooding protocol messages). The Routing and Flooding MPRs can be decided, updated and calculated using the Routing MPR Computation and Flooding MPR Computation respectively.



iii. **Network Topology Information Sharing:** Topology control messages contains the entire topology information. The process of sending this information to all the nodes in the network is called Network Topology Information Sharing.

iv. **Routing table preparation:** It is the process of selecting the best possible route to all destinations using 1-Hop neighbour, 2-Hop neighbour and Topology information. The figure 3 shows the Routing MPR selection flow chart.

3. SCENARIO DESCRIPTION

We consider multinet MANET environment where there is a requirement of communication

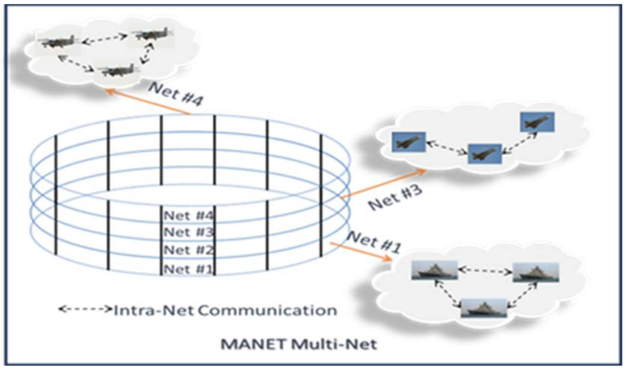


Figure 4: Multi-net MANET operational scenario

between the various nets. In a military scenario, the net member may be a part of a squadron consisting of ships acting as C2 platforms exchanging EW (Electronic warfare) messages. The other group may be of helicopters exchanging helicopters to helicopters data. The advantage of this multinet environment is that multiple groups as a part of a Net may exist in the same geographical location simultaneously and they may communicate or do data transfer at the same time. The nodes in the network are divided into different mutually exclusive nets. The nodes of a net will primarily communicate with their own net (Normal node network). The leader node in a network will be used for communication across the nets (Leader node network). The leader node

performs two types of routing normal as well leader network routing. The figure 4 describes a typical multinet MANET communication scenario. The communication primarily consists of voice with low latency in broadcast mode, C2 (command and control), SMS, SA messages and IP services in a multi hop environment. The services requirement is of low latency and multihop data communication in a multinet scenario. The control overhead has to be reduced for bandwidth constrained systems. The latency and update rate requirements has to be met

Figure 3: OLSRv2 Routing MPR Selection

in a multinet environment where multiple systems are communicating with each other, for efficient transmission of these communication services an optimized routing protocol is required. Table 2 describes the service details of the various services supported.

Table 2. Service Details

Service Name	**Mode**	**Details**
Voice	Broadcast	• Multihop • Low Latency
Command and Control (C2) Message	Unicast Broadcast	• Multihop • Tactical Real Time
SMS	Unicast	• Multihop • Low Latency

Situational Awareness (SA) Message	Broadcast	• Multihop • Tactical Real Time
IP data (File transfer, Image transfer)	As per IP	• Multihop

4. OLSR V2 OPTIMIZATIONS

Optimization of OLSR is done at various levels which include the following:

i. **Header optimization**:

Hello message specifies a protocol message that is used to establish the connectivity to its 1-hop and symmetric 2-hop neighbors. Hello messages are disseminated from time to time at an interval known as hello interval. Aim is to reduce the number and size of control messages in the Hello message packet. Table 3 shows the optimized hello message packet structure used in implementation.

Table 3. Hello Message Packet Structure

Hello Message			
Byte 1	Byte 2	Byte 3	Byte 4
Message Type	Message Length	Originator Address	
Hop Limit	Message Sequence Number		Validity Time
Reserved	MPR Willingness	Common Address Data	Neighbor Set Size
Unique Id	Link Type	Link Metric	

Hello messages are sent in the OLSR packet. Reduction in the size and number of parameters of Hello message header field limits the number of control messages transmitted for neighborhood discovery and link sensing which leads to efficent utilization of bandwidth.

In a network, Topology Control (TC) messages and MPR relaying are utilized for disseminating the neighbor information. TC messages are produced and disseminated by Routing MPRs. Table 4 shows the optimized TC Message Packet Structure.

Table 4. TC Message Packet Structure

Topology Control Message			
Byte 1	Byte 2	Byte 3	Byte 4
Message Type	Message Length	Originator Address	
Hop Limit	Message Sequence Number		Validity Time
Reserved	Advertised neighbor sequence number		Tc Message Type
Common Address Data	Neighbor Set Size	Unique Id	Common Data
Link Metric			

ii. **Message Transmission Interval Optimization:**

HELLO messages disseminated on OLSRv2 interfaces include originator address, link metrics, and MPR selection information.TC messages are disseminated by their originating router proactively at a regular interval, on all OLSRv2 links. Table 5 shows the optimized message transmission intervals.

Table 5. Message Transmission Interval

Message Interval Parameters in Initial Stage:	Message Interval Parameters in Stable Network Stage:
M_HELLO_INTERVAL: =1 sec	M_HELLO_INTERVAL: =5* M_HELLO_INTERVAL
M_TC_INTERVAL: =2 sec	M_TC_INTERVAL:=5* M_TC_INTERVAL
M_HL_VALID_TIME_INIT: =3* M_HELLO_INTERVAL	M_HL_VALID_TIME_STBL: =5*M_HL_VALID_TIME_INIT
M_TC_VALID_TIME_INIT: =3* M_TC_INTERVAL	M_TC_VALID_TIME_STBL: =5*_TC_VALID_TIME_INIT

Change in the announced symmetric 1 hop neighbourhood or a change in the router itself also leads to transmission of TC messages. Inconsistency in the transmissions of TC messages is permissible by the protocol as TC messages are transmitted at regular intervals. In a highly dynamic network, and in the initial network setup stage Hello and TC messages may be transmitted more often. Once the network has become stable the transmission interval of these messages can be increased. The above values in table 5 are given as sample. They can be changed to serve various deployment scenarios. Bandwidth constrained network connections shall be using longer message intervals, whereas a high mobility network shall be using shorter message intervals.

iii. **Embedding of the Hello Message in the MAC (Media access layer) control packet:**

Network Layer and MAC Layer are closely inter-related. So, the control information that is included in MAC Layer may be used by Network Layer as such. Table 6 shows the details of OLSR v2 control packet parameters and fields which can be embedded as a part of MAC control packet.

Table 6. OLSR v2 Control Packet Parameters

Message Fields	Inclusion in MAC/Complete Removal (CR)
Message Type (Hello)	CR
Message Length	MAC
Originator Address	MAC
Hop Limit	MAC
Message Sequence No	MAC
Validity Time	MAC
Reserved	CR
MPR Willingness	CR
Common Address Data	MAC
Neighbor Set Size	MAC
Unique Id	MAC
Link Type	MAC
Link Metric	MAC

Cross layer optimization involves optimization of the control layer packets and identifying the common control info so as to reduce the control packet transmission if the layers are in close coordination with each other.

5. MPR UTILIZATION IN OLSR V2

OLSRv2 Protocol specifies two types of MPRs [7]. They are Routing and Flooding MPRs which are used to acquire flooding and topology reduction. Routing MPR selection involves

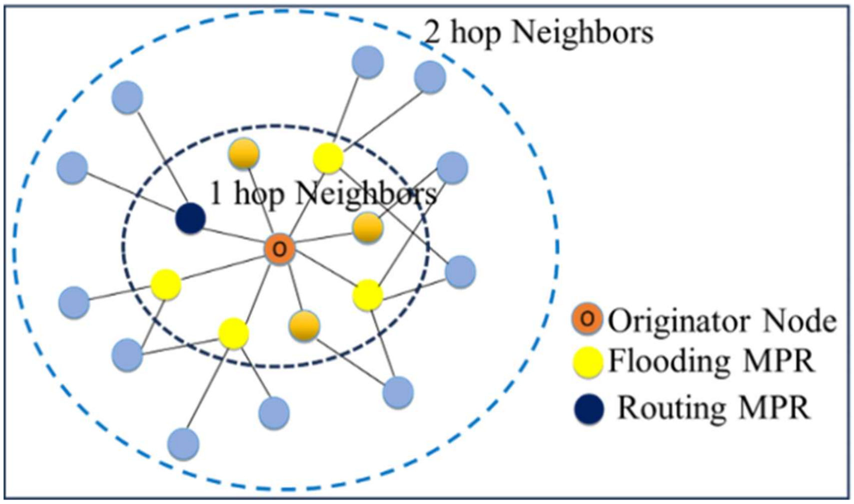


Figure 5: OLSR v2 Message transfer scenario

those links that have good in link i.e., it is selected as receiver perspective. Flooding MPR selection involve those links that have good out link i.e., it is selected as transmitter perspective. Thus, unicast data is transmitted through Routing MPRs and Broad cast and Multi cast data is transmitted through Flooding MPRs. OLSRv2 is used for multiple topologies and multiple services [8]. Example involves sending of VOIP data over multiple hops using these Flooding MPRs and sending of unicast messages such as SMS through Routing MPRs. The message transfer using the MPRs is depicted in the figure 5 below.

6. CONCLUSION:

The paper presents some of the optimizations in the utilization of OLSR V2 for providing QoS services and efficient utilization of channel bandwidth in multinet MANET scenario. The optimizations in HELLO and TC packets reduces the effective size of control payload which leads to efficient utilization of constrained channel bandwidth. Considering the different scenarios during the network setup and after the network is formed, we setup different periodicity for HELLO and TC packets transmissions. This led to faster network convergence during the network setup and reduces the packet transmission frequency after network is stabilized. The HELLO packet information is embedded in MAC control packet, this eliminated the need of sending the HELLO packet separately. These optimizations improve the performance of MANET in terms of channel utilization and cross layer information sharing. Another advantage that we got in providing the QoS to different services through the efficient utilization of MPRs. The combination of MPRs and efficient slot planning at the MAC level ensures that the stringent latency requirement of PTT voice of the order of 120 millisecond can be met easily. The MPRs also reduces the excessive flooding in the network for broadcast and multicast data and voice services. Further, work is required to be carried out to quantify the overall performance improvement gained by these optimizations. In order to apply these optimizations in different multinet scenarios, we plan to extend this work through the use of network simulation tool.

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