OLSR Protocol with Cross Layer Design in MANET

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***Abstract*-- The Optimized Link State Routing (OLSR) is a table-driven and proactive routing protocol that was designed for mobile ad hoc network. OLSR protocol is an optimization of the pure link state algorithm. The key concept used in the protocol is that of Multi Point Relays (MPRs) which are selected nodes that forward broadcast messages during the flooding process. This technique substantially reduces the message overhead as compared to a pure flooding mechanism where every node retransmits messages throughout the network. In an effort to improve the performance of wireless networks, there has been increased interest in protocols that rely on interactions between different layers. Cross-Layer Design has become the new issue in wireless communication systems as it seeks to enhance the capacity of wireless networks significantly through the joint optimization of multiple layers in the network.**

***Keywords*- OLSR, Cross-Layer, MANET, Routing**

I. INTRODUCTION

Mobile ad hoc network (MANET) consisting of mobile hosts only has attracted much attention recently. In MANET, the nodes themselves are responsible for routing and forwarding of packets. If the nodes are out of range from each other, and therefore are not able to communicate directly, intermediate nodes are needed to make up the network in which the packets are to be transmitted. Examples of MANETs include emergency operations where there exist no infrastructure and military operations where the existing infrastructure might not be trusted.

The design of efficient routing protocols is a critical issue for MANET having no fixed topology. Therefore, the source - initiated on demand routing protocol, which establishes the route between the source and the destination only when the source demands that, becomes the most popular routing protocol in the MANET. The layered concept (for example OSI) was primarily created for wired networks and naturally follows their architectural design. Designing wireless networks with strict layering principle did not ful fill the expectation raised in wire-line network design. The ad hoc mobile networks oppose strict layered protocol design because of their dynamic nature, infrastructure-less architecture, limited resources, mobility of nodes and time varying unstable links and topology. The concept of cross-layer design is based on architecture where the layers can exchange information in order to improve the overall network performances [1].

1.1 Manet & Routing Protocol

The term MANET stands for Mobile Ad-hoc Network. Ad hoc wireless networks are defined as the category of wireless networks that utilize multi-hop radio relaying and are capable of operating without the support of any fixed infrastructure (infrastructure less networks). The absence of any central coordinator or base station makes the routing a complex one compared to cellular networks. Each node acts as a host and a router at the same time. This means that each node participating in a MANET commits itself to forward data packets from a neighboring node to another until a final destination is reached. These networks are deployed 'on the fly' [2][3].

Among the issues of Adhoc Wireless Networks, routing is one of the key features. Since the network is dynamic and channel state is continuously changing, discovering the appropriate path for data transfer is very important. The MAC for 802.11b uses CSMA/CA for accessing the channels by different nodes. But, one of the major concerns is not only selecting the nodes along with the path from source to destination but also pick those nodes in such a way, that, they provide best service in the form of relaying data with high rate, least error and least time. As such, this research mainly focuses on the routing issue.

1.2 Classification of Routing Protocols

Routing protocols for MANETs can be classified into several types based on different criteria. Based on routing information update mechanism, they can be categorized as follows [4]:

A. Table Driven-Proactive

Every node maintains the network topology information in the form of routing tables by periodically exchanging routing information. The routing information is generally flooded in the network. Whenever a node requires a path to a destination, it runs in an appropriate path finding algorithm on the topology information it maintains. Examples of such protocols are DSDV, OLSR, WRP etc. Such protocols have both advantages and disadvantages eg. Availability of routes to all destinations at all times facilitates route setup quickly. But, it has excessive control overhead which is proportional to the number of nodes in network.

B. Reactive or On-demand routing protocols

Such protocols do not maintain the network topology information. They only obtain the necessary path on requirement basis. As a result these protocols do not exchange routing information periodically. Examples are: DSR, AODV etc. While such protocols may be taking time to establish routing path, they have much lesser control overhead. They are the classical distance vector protocols.

II. OPTIMIZED LINK STATE ROUTING PROTOCOL (OLSR)

2.1 Introduction of OLSR

The information in this section concerning the Optimized Link State Protocol is taken from its RFC 3561 [2]. Optimized Link State Protocol (OLSR) is a proactive routing protocol, so the routes are always immediately available when needed. OLSR is an optimization version of a pure link state protocol. So the topological changes cause the flooding of the topological information to all available hosts in the network. To reduce the possible overhead in the network protocol uses Multipoint Relays (MPR). The idea of MPR is to reduce flooding of broadcasts by reducing the same broadcast in some regions in the network, more details about MPR can be found later in this chapter. Another reduce is to provide the shortest path. The reducing the time interval for the control messages transmission can bring more reactivity to the topological changes. [5, 6, 7, 8, 9, 10, 11]

OLSR uses two kinds of the control messages: Hello and Topology Control (TC). Hello messages are used for finding the information about the link status and the host's neighbours. With the Hello message the Multipoint Relay (MPR) Selector set is constructed which describes which neighbours has chosen this host to act as MPR and from this information the host can calculate its own set of the MPRs.the Hello messages are sent only one hop away but the TC messages are broadcasted throughout the entire network. TC messages are used for broadcasting information about own advertised neighbours which includes at least the MPR Selector list. The TC messages are broadcasted periodically and only the MPR hosts can forward the TC messages.[8,9,10,11,12]

There is also Multiple Interface Declaration (MID) messages which are used for informing other host that the announcing host can have multiple OLSR interface addresses. The MID message is broadcasted throughout the entire network only by MPRs. There is also a "Host and Network Association" (HNA) message which provides the external routing information by giving the possibility for routing to the external addresses. The HNA message provides information about the network- and the net mask addresses, so that OLSR host can consider that the announcing host can act as a gateway to the announcing set of addresses. The HNA is considered as a generalized version of the TC message with only difference that the TC message can inform about route cancelling while HNA message information is removed only after expiration time. The MID and HNA messages are not explained in more details in this chapter, the further information concerning these messages can be found in [12]

2.2 Routing

2.2.1 Neighbour Sensing

The link in the ad hoc network can be either unidirectionalor bidirectional so the host must know this information about the neighbours. The Hello messages are broadcasted periodically for the neighbour sensing. The Hello messages are only broadcasted one hop away so that they are not forwarded further. When the first host receives the Hello message from the second host, it sets the second host status to asymmetric in the routing table. When the first host sends a Hello message and includes that, it has the link to the second host as asymmetric, the second host set first host status to symmetric in own routing table. Finally, when second host send again Hello message, where the status of the link for the first host is indicated as symmetric, then first host changes the status from asymmetric to symmetric. In the end both hosts knows that their neighbour is alive and the corresponding link is bidirectional.[9,12]

The Hello messages are used for getting the information about local links and neighbours. The Hello messages periodic broadcasting is used for link sensing, neighbour's detection and MPR selection process. Hello message contains: information how often the host sends Hello messages, willingness of host to act as a Multipoint Relay, and information about its neighbour. Information about the neighbours contains: interface address, link type and neighbour type. The link type indicates that the link is symmetric, asymmetric or simply lost. The neighbour type is just symmetric, MPR or not a neighbour. The MPR type indicates that the link to the neighbour is symmetric and that this host has chosen it as Multipoint Relay. [12]

2.2.2 Multipoint Relays

The Multipoint Relays (MPR) is the key idea behind the OLSR protocol to reduce the information exchange overhead. Instead of pure flooding the OLSR uses MPR to reduce the number of the host which broadcasts the information throughout the network. The MPR is a host's one hop neighbour which may forward its messages. The MPR set of host is kept small in order for the protocol to be efficient. In OLSR only the MPRs can forward the data throughout the network. [12]

Each host must have the information about the symmetric one hop and two hop neighbours in order to calculate the optimal MPR set. The Fig. 1 is taken from [6] to illustrate these concepts. Information about the neighbours is taken from the Hello messages. The two hop neighbours are found from the Hello message because each Hello message contains all the hosts' neighbours. Selecting the minimum number of the one hop neighbours which covers all the two hop neighbours is the goal of the MPR selection algorithm. Also each host has the Multipoint Relay Selector set, which indicates which hosts has selected the current host to act as a MPR. [8,10,11]

When the host gets a new broadcast message, which is need to be spread throughout the network and the message's sender interface address is in the MPR Selector set, then the host must forward the message. Due to the possible changes in the ad hoc network, the MPR Selectors sets are updated continuously using Hello messages. [12]

2.2.3 Multipoint Relays Selection

In this section the proposed algorithm for the selection of Multipoint Relay set is described. This algorithm is found from [2]. The algorithm constructs the MPR set which includes minimum number of the one hop symmetric neighbours from which it is possible to reach all the symmetrical strict two hop neighbours. The host must have the information about one and two hop symmetric neighbours in order to start the needed calculation for the MPR set. All the exchange of information are broadcasted using Hello messages. The neighbours which have status of willingness different than WILL_NEVER in the Hello message can be chosen to act as MPR. The neighbour must be symmetric in order to become an MPR.

Proposed algorithm for selecting Multipoint Relay

1. Take all the symmetric one hop neighbours which are willing to act as an MPR.
2. Calculate for every neighbour host a degree which is a number of the symmetric neighbours, that are two hops away from the calculating source and does not include the source or its one hop neighbours.
3. Add the neighbour symmetric host to the MPR set. If it is the only neighbour from which is possible to get to the specific two hop neighbour, then remove the chosen host neighbours from the two hop neighbour set.
4. If there are still some hosts in the two hop neighbour set, then calculate the reach ability of the each one hopneighbour, meaning the number of the two hop neighbours, that are yet uncovered by MPR set. Choose the node with highest willing value, if the values are the same then takes the node with greater number of reach ability.If the reachability is the same, then take the one with greater degree counted in the second step. After choosing the neighbour for MPR set remove the reachable two hop neighbour from the two hop neighbour set.
5. Repeat previous step until the two hop neighbours set is empty.
6. For the optimization, set the hosts in the MPR set in the increasing order basing on the willingness. If one host is taken away and all the two hop neighbours, covered by at least one host and the willingness of the host is smaller than WILL_ALWAYS, then the host may be removed.

The possible improvements of this algorithm are needed, for example, when there are multiple possible interface addresses for one host [12]. The finding the optimum MPR set for the two hop neighbour coverage is considered to be an NP problem based on [8,10,11]

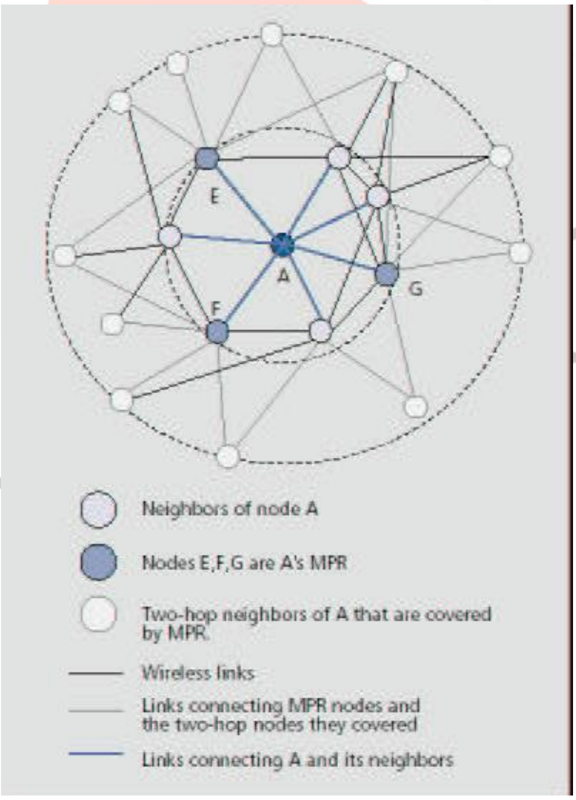


Fig 1 OLSR

2.2.6 Advantages

OLSR is also a flat routing protocol, it does not need central administrative system to handle its routing process. The proactive characteristic of the protocol provides that the protocol has all the routing information to all participated hosts in the network. However, as a drawback OLSR protocol needs that each host periodic sends the updated topology information throughout the entire network, this increase the protocols bandwidth usage. But the flooding is minimised by the MPRs, which are only allowed to forward the topological messages.

The reactiveness to the topological changes can be adjusted by changing the time interval for broadcasting theHello messages. It increases the protocols suitability for ad hoc network with the rapid changes of the source and destinations pairs. Also the

OLSR protocol does not require that the link is reliable for the control messages, since the messages are sent periodically and the delivery does not have to be sequential. [5,7]

Due to the OLSR routing protocol simplicity in using interfaces, it is easy to integrate the routing protocol in the existing operating systems, without changing the format of the header of the IP messages. The protocol only interacts with the host's Routing Table. [5,7]

OLSR protocol is well suited for the application which does not allow the long delays in the transmission of the data packets. The best working environment for OLSR protocol is a dense network, where the most communication is concentrated between a large number of nodes.

OLSR has also extensions to allow for hosts to have multiple OLSR interface addresses and provide the external routing information giving the possibility for routing to the external addresses [12]. Based on this information there is possibility to have hosts in the ad hoc network which can act as gateways to another possible network.

III. WHAT IS CROSS-LAYER DESIGN (CLD)?

As per as the architecture is concern, it plays a vital role in the designing of a system. Architecture in system design pertains to breaking down the system into modular components systematically specifying the interactions between the components. The significance of the architecture is difficult to exaggerate. Modularity provides the abstractions needed for the designer to understand the overall system. With the abstraction of the system it is easy to develop and design it concurrently with fewer efforts. Designers can focus their effort on a specific part with an assurance that the entire system will be assemble by joining all the subparts and will interoperate. A good architectural design can thus lead to quick proliferation. On the other hand, taking an architectural shortcut can often lead to performance gain. Thus there is always a fundamental tug-off between the performance and architecture and there exist a temptation to violate the architecture. However, architecture can also be regarded as performance optimization, although it takes a longer span of time. An architecture that allows enormous proliferation can lead to very low per-unit cost for a given performance. This lead to a trade-off between the realization of short-term vs the long-term gains. The most famous architecture is the OSI Model and the well known TCP-IP Model. The OSI Model consists of seven layers viz. Application layer, Presentation layer, Session layer, Transport layer, Network layer, Data Link layer and Physical layer. However the TCP-IP consists of five layers in which the upper three layers of the OSI model is merged as a super layer "Application layer".

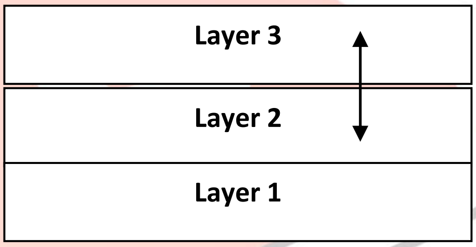


Fig 2 Cross-layer design between layer2-3

Traditionally, network protocols are divided into independent layers. Each of these layers is designed separately and the interactions between these layers are performed with the help of well defined interfaces. In the layered architecture, UDP packets are sent to and fro from the network layer to the application layer via the transport layer. This communication causes some avoidable delay which degrades the overall performance of the network. If we can design a direct application layer- network layer interface bypassing the transport layer, we can save the end to end delay and hence the overall network performance can be improved. Designing such interfaces is a cross-layer communication. Cross layer design refers to protocol design done by actively exploiting the dependence between the protocol layers to obtain better performance gain. This is unlike the layered architecture where the protocols at the different layers are designed independently and do not depend on the other layer protocol. In the layered protocol stack each layer communicates only with the adjacent layers using well defined interfaces and hence there is no performance optimization. Performance optimization can be obtained with the help of adaptation and optimization using the available information across many protocol layers.

In a layered architecture, the designer has two choices at the time of the protocol design. Firstly protocol can be designed by respecting the rules of the reference architecture i.e. designing a protocol such that the higher layer protocol only make use of the services at the lower layers and is not concerned about the details of how the service is being provided. Secondly, protocols can be designed by violating the reference architecture, for example by allowing direct communication between protocols at the nonadjacent layers. Such violation of the layered architecture is cross layer design with respect to the reference architecture.

IV. CHALLENGES INVOLVED IN CROSS-LAYER DESIGN (CLD)

Here we will be discussing the challenges offered by the architecture to the researchers. For pointing out the challenges in this section, we came across various design proposals given in the literature and found some initial ideas on how cross-layer interaction can be implemented. The following are the challenges:

- How to identify the most important cross-layer design technique which best fit for our model?
- How to achieve better network performance?

- Have we made the cross-layer proposal after a detailed study keeping in mind all the effects of the layer-interaction on the parameters of different layers and on the overall network?
- Which layers of the protocol stack should be involved in the cross-layer proposal?
- Whether we should go for the deployment of new interfaces bypassing the adjacent layers or for merging of layers?
- How these non-adjacent layers will communicate with each other?
- What information should be exchanged across protocol layers and how frequently this information exchange should take place?
- What are the adequate / efficient procedures to exchange this information?
- How to counter the loss of the respective header which will be lost when direct communication takes place between the non-adjacent layers?
- What is the trade-off between the improved network performance and the loss of modularity?

V. FLOWCHART FOR CROSS-LAYER PROPOSED METHOD FOR OLSR ROUTING PROTOCOL IN MANET

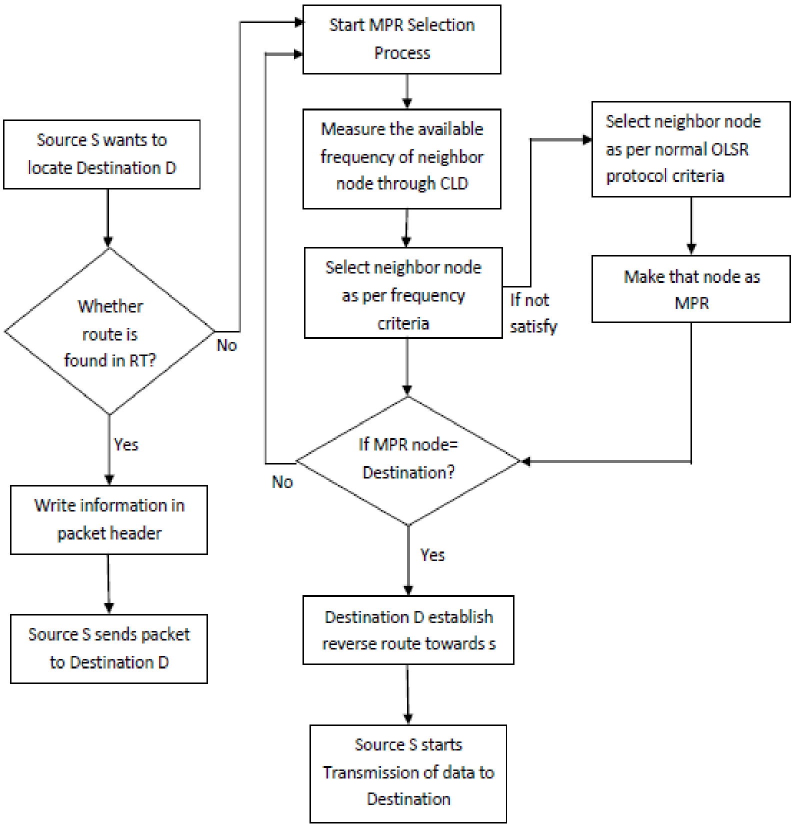
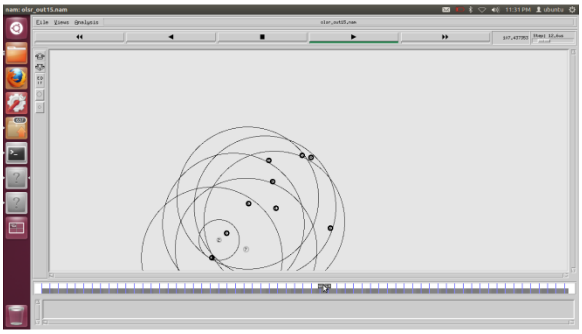
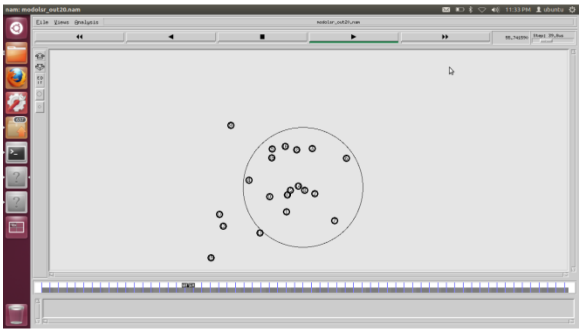


Fig 3 Flowchart

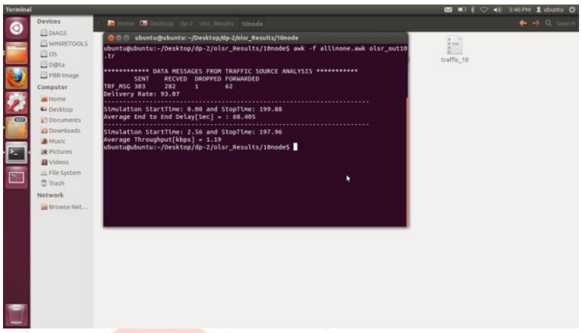
VI. IMPLEMENTATIONS RESULTS



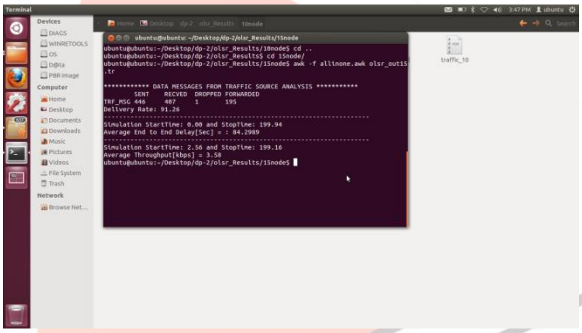
15node OLSR nam



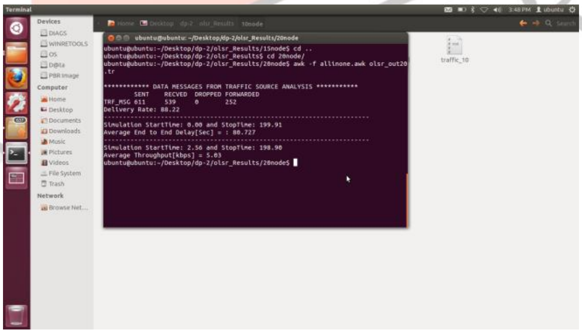
20node CLD_OLSR nam



10node OLSR Results



15node OLSR Results



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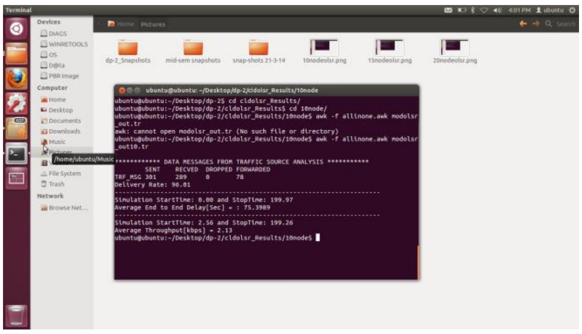
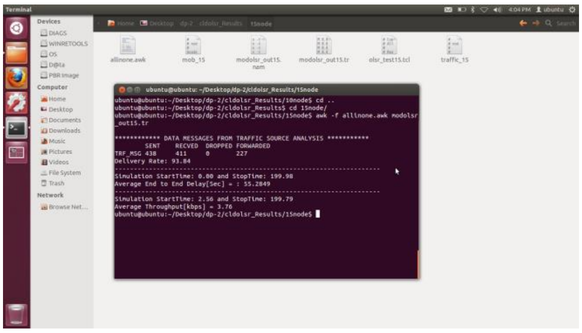


10node CLD_OLSR



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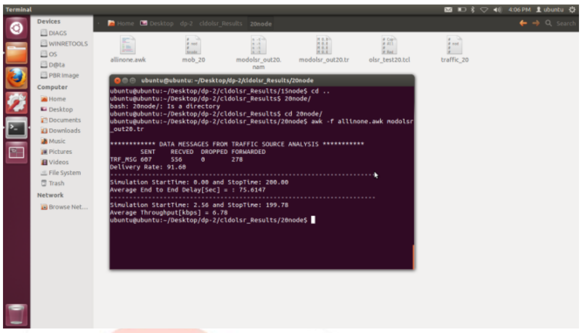

20node CLD_OLSR

VII. CONCLUSION

This paper shows that For mobile wireless networks The performance of a routing protocol is coupled with factors, like the choice of physical technology ,link layer behavior ,etc The overall behaviour of a protocol specifies its working domain for which it could be suitable .OLSR protocol is proactive or table driven in nature, hence it favors the networking context where this all time-kept information is used more and more .The procotol also goes in favoure of the applications which do not allow long delays in transmitting data packets .OLSR protocol is adapted to the network which is dense, and where the communication is assumed to occur frequently between a large number of nodes.

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