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Energy and Congestion Conscious Transmissions and Routing in SANETs and MANETs: A Survey

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***Abstract*—Mobile Ad-hoc Networks (MANETs) are the most dynamic environment networks on account of mobility of nodes, dynamic topology changes, limited energy consumption and bandwidth constraints. These are the self-organizing capability of mobile nodes which are connected through wireless links. In these networks, while transmitting data packets, congestion and route disconnections can be occurred which results in higher multiple packet losses, huge end-to-end (ETE) delay and huge network overhead. This paper an attempt to study about the proposed congestion control and energy aware routing schemes in MANETs.**

***Keywords*— Congestion, Ad-Hoc Network, Transmissions;**

I. INTRODUCTION

In recent years, mounting demands of unconventional user has led to the upsurge in advancements of wireless communication technology. Wireless Networks are in use since 1980's. In the past, there are numerous generations (e.g., 1st, 2nd, 3rd, and 4th) has come into the picture and the improvements in these systems have been done day-by-day. In the field of networking, wireless networks are the evolving system that continuously allow users to access services and information regardless of their geographic positions. These systems played an important role in the modern communication arena because these networks can be easily deployed with low preliminary cost and can be possible on those areas where the possibility of wired communication is almost impossible. Although, there are different advantages linger with these systems, but, they too possess different drawbacks (which we will discuss it in later sections). There are two variations in wireless networks (I). *Infra-structured networks* (II). *Infra-structure less networks*. The infra-structured networks are those networks that have fixed criteria of communication between devices, while, infra-structure less networks are those networks that does not have fixed criteria of communication between devices.

II. MANET PRELIMINARIES

These are the networks which are having self configuring or self organizing capability of mobile nodes which are attached through a wireless links. In these networks, the nodes have the capability of performing independent movement (i.e., because of mobility) and can connect with any node in random fashion in the network terrain. These networks are highly variable in nature, can be dynamically deployed anywhere at a particular instant of time. In these networks, communication can either be done in two ways: (I). *Multi-hop communication* (II). *Single-hop communication*. In single-hop communication, two wireless nodes can directly be communicated with each other. While, in multi-hop communication, the mobile nodes can indirectly be communicated through intermediate nodes. Mostly multi-hop communication take place in MANETs, because of limited transmission competences of the nodes [1] [2]. In MANETs, routing protocols can be categorized into three variations i.e. (I). Proactive protocols, (II) Reactive protocols and (III) Hybrid protocols. The table-driven or proactive routing protocols are Destination Sequenced Distance Vector Routing (DSDV) [3], Global State Routing (GSR) [4], Fisheye State Routing (FSR) [5] etc. The reactive or on-demand routing protocols are Dynamic Source Routing (DSR) [6], Ad-hoc On-demand Distance Vector Routing (AODV) [7] etc. and hybrid protocol is Zone Routing Protocol (ZRP) [8]. In these abovementioned routing protocols, the routing strategies are mainly follows multi-hop communication paradigm. When destination is far away from source and there is no possibility of direct communication between source and destination.

A. Congestion and its Effects in MANETs

Congestion can be defined as the particular condition occurs in network or in small part of network, that, traffic intensity becomes so high which causes drastic decrement of overall network's performance and reaction time. There are multiple effects of congestion in the networks: (I). *Multiple packet losses,* (II) *High ETE delay* (III). *High Network Overhead*. In case of on-demand Layer-3 routing protocols, the routes have been created dynamically when needed, i.e., when the source needs to send data to destination, then it brings into play the route discovery scheme to find an optimal path. The route or the connection has been valid until the data to be transmitted entirely. Nevertheless, there can be the possibility that a particular intermediate or group of intermediate nodes becomes congested and hence, it causes the overall throughput performance degradation. The abovementioned issues become more noticeable in bulk data transmission such as multimedia (e.g., audio and video) data, where the packet losses become more probable and the undesirable effects of congestion on Quality of Service (QoS) is of more significance [1]. Hence the possibility of congestion should always be taken in account while designing any routing strategies, especially in case of MANETs.

III. CONGESTION MANAGEMENT TECHNIQUES

Based on congestion, the routing strategies can also be categorized into two alternatives i.e. (I). *Congestion Adaptive Routing (CAR)* (II) *Congestion Non-Adaptive Routing (CNR)* strategies [1]. The present routing protocols comes under the category of CNR. Further, Raghavendra and Tran [9], and Tran and Raghavendra [10] have extensively presented and evaluated the CAR concept. In CAR, every wireless node which takes part in the route notifies its down-stream node when susceptible to be congested. Then the down-stream node tries to bypass that potential congested region to the first non-congested wireless node on the main path (shown in Fig. 1). However, traffic- splitting has been done in probabilistically fashion over available routes, thus effectually shrinking the chances of congestion occurrence.

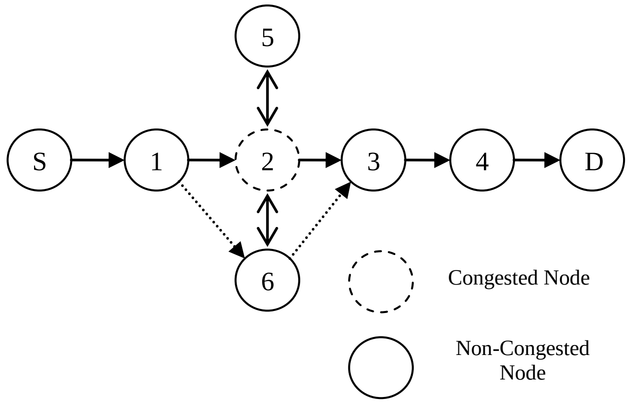

Figure 1. Bypassing to Avoid Congestion Area

In wired network environment, the new idea i.e., load-balancing, tries to reduce congestion with the aim of improving network throughput performance. Instead, mobility of wireless nodes causes a major issue in load-balancing and a dynamic scheme is indeed needed. In the past, numerous traffic-based load-balancing techniques such as Dynamic Load-Aware Routing (DLAR) [11], Associativity Based Routing (ABR) [12], Traffic Size Based (TSB) [13] and Load Balanced Ad-hoc Routing (LBAR) [14] have been suggested with the aim of reducing congestion in the network. Nevertheless, in MANETs and Static Ad-hoc Networks (SANETs), unlike the scenario of wired network, even control packets for load-balancing can seriously cause network overheads. Hence, for this Yoo *et al*. [15] have given Simple Load-Balancing approach (SLBA) which efficiently tries to improve the lifetime of mobile station by avoiding high traffic concentrations over few mobile stations. Moreover, DSR and AODV do not explore new paths providing current paths are available, and there can be the possibility that the current paths could get congested. Hence, SLBA approach permits each mobile station to take decision whether it is heavily congested or not and appropriately let some other mobile station undertake traffic load.

Since the whole-sole objective of load-balancing schemes is to extend the life-time of a route and that subsequently extends the life-time of a network, the energy-aware routing schemes do have the similar definitive objective. Hence, several energy-aware routing schemes include Power Aware Multi-Access Protocol with Signaling (PAMAS) [16], Sensor- MAC (S-MAC) [17] [18], Timeout-MAC (T-MAC) [19], Min-

Max Battery Cost Routing (MMBCR) [20], Probing Environment and Adaptive Sleeping (PEAS) [21], Energy Level Based Routing Protocol (ELBRP) [22-24], Sharma and Kumar [25], Sharma *et al*. [26], Minimum Total-transmission Power Routing (MTPR) [27], and Conditional Max-Min Battery Cost Routing (CMMBCR) [28] etc. These aforementioned schemes unswervingly assume that all the mobile stations in dynamic networks (e.g., MANETs) collaborate for a common objective. Nevertheless, Buttyán and Hubaux [29] and Marti *et al*. [30] have revealed that some selfish mobile stations may ignore or not further forwarded others' packets to save their personal resources. Hence, many attempts [29-34] have been done in the past for solving this problem.

Traditionally, drop tail queuing system have been widely used for queue management in the system, that works over the simple concept of First in First Out (FIFO) concept in which packets have been dropped from the tail when the queue gets full. But, there had different drawbacks associated with this concept, i.e., huge delay associated because each packet remains in the queue until it processed, causes high instability in the system at the instance of occurrence of congestion and more packets drop in the network. Active Queue Management (AQM) technique is used in place of drop tail queuing mechanism so that it can tackles with such drawbacks, i.e., system instability, huge delay, multiple packet losses and low link utilization [35]. In order to detect congestion well in advance, Random Early Detection (RED) [36] Algorithm was suggested. The main aim of this algorithm is to detect congestion early and to convey this information to the sender node so that it reduces its sending rate.

A. Conventional and Cross Layering Standard based Congestion Control Schemes in MANETs/SANETs

Specifically, the conventional IEEE 802.11 standard [37] signifies the prominent solution given that communications on SANETs and MANETs. Nonetheless, the main constraint present in this orthodox standard is the restriction of dynamic network to the circumstance when all the mobile stations are positioned within the transmission and interference range of each other. However, continuing research overcame these limitations, allowing packet delivery over ETE path which consist of multiple wireless mobile nodes. Further Transmission Control Protocol/Internet Protocol (TCP/IP) reference model delineates the fixed set of protocols that facilitate network communication. However, no layer in TCP/IP reference model has comprehensive and real-time knowledge about network available resources. Hence, for this purpose, the sender can control or circumvent congestion based on network congestion feedback [38]. The leading Layer-4 protocols in the Internet are TCP [39] and User Datagram Protocol [40] and is actively utilized by the range of applications. Moreover, initially, TCP's design was originally aimed for wired networks where packet losses follow typically due to congestion. However, TCP's performance gets significantly affected when it is being deployed over wireless networks. Because it treats every loss as a buffer-overflow (congestion) induced loss, while, in wireless networks there are many reasons for a packet being drop [41]. Hence, TCP's reaction to packet losses should be appropriate and more adaptive in nature. Hence, considering this as a problem, many researchers [38] [42-50] in the past have put their efforts to improve the TCP's performance in wireless networks, especially in SANETs and MANETs. Recently, various multi-path Layer-4 protocols (e.g., MP-TCP [51-53] and SCTP [54]) development leads to much more performance to that of single-path Layer-4 protocols by combining the available bandwidth of all the available interfaces (see References [55-57] for in-depth detail).

IV. CONCLUSION

MANET relies over mobile nodes which act as routers that carries the data for other nodes in the networks but the main problems of MANET are redundant reasons for packet drops, dynamic topology changes due to rapid movement of nodes in the networks, bandwidth and energy constrained strategies make it more difficult to cope up with these problems in these networks which leads to highly vibrant nature networks, this dilemma causes congestion related problems which leads to multiple packet losses, high overhead and ETE delay in the network. To solve congestion related problems in MANETs, several techniques have been suggested so far and requires much more work in near future as well.

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