Research Article

ROUTING BASE CONGESTION CONTROL METRICS IN MANETS

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ABSTRACT

Mobile adhoc network is self-configurable and adaptive. Due to node mobility we cannot predict load on the network which leads to congestion, one of the widely researched area in manets. A lot of congestion control techniques and metrics have been proposed to overcome it before its occurrence or after it has occurred. In this survey we identify the currently used congestion control metrics. Through this survey we also propose a congestion control metric RFR(resource free ratio) which considers three most important parameters to provide congestion free route discovery. Further we show the results of node selection based on fuzzy logic calculations using the proposed metric.

Keywords: Congestion, manets, metric, RFR, fuzzy logic, Survey.

INTRODUCTION

Mobile adhoc network is a collection of mobile nodes which are self-organizeable and configure itself on the fly. For their lack of infrastructure these networks are quick to deploy environment and provide applications in diverse domains. Since their inception they have been deployed in military areas, emergency and rescue operations, business applications and many more, just because they are economical.

The above figure [20] shows a simple adhoc network. In these networks, a mobile terminal has dual functions of a node and routing. Routes are generally broken due to node movements, load on the network, insufficient bandwidth, power insufficiency, etc. Also wireless links are unreliable and prone to errors. All these factors lead to congestion in the networks which jams the network and affects its performance. Routing algorithms should adapt to such dynamic environment and provide quality of service and error free delivery. Congestion and load balancing are challenging tasks due to unpredictable nature of these networks.

Congestion control [18] concerns controlling traffic entry into a telecommunications network, so as to avoid congestive collapse by attempting to avoid oversubscription of any of the processing or link capabilities of the intermediate nodes and networks and taking resource reducing steps, such as reducing the rate of sending packets. It should not be confused with flow control, which prevents the sender from overwhelming the receiver. Congestion control is a key issue in mobile adhoc networks.

In a network with limited shared resources and bandwidth, it is necessary to adjust the data rate used by each user in order not to overload the network. To address these issues in manets many approaches have been proposed in the literature. There are two approaches used efficiently to control routing in manets, the standard TCP with supportability for wireless networks and other through routing protocols.

In this paper we give an overview of the existing proposals and metrics, their key ideas and show their interrelation.
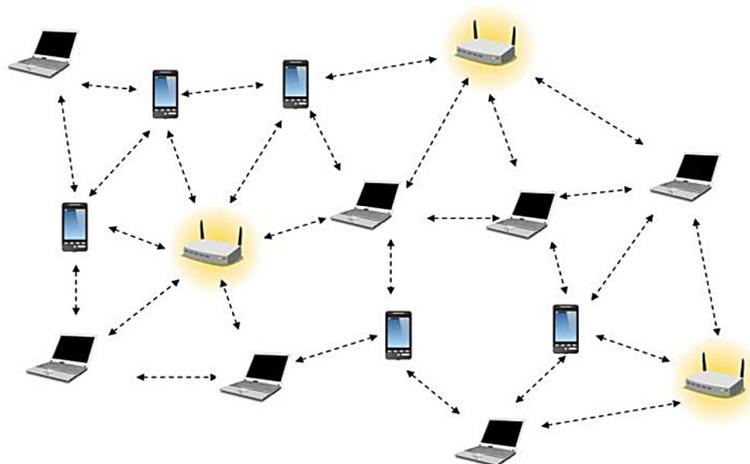
Fig. 1. Mobile Adhoc Network

RELATED WORK

In recent years many researchers have tried to improve the congestion control mechanisms. The main goal of any congestion control algorithm is to balance the traffic to maximize throughput, packet delivery ratio and minimize end to end delay and packet drops.

TCP is the most popular end-to-end protocol which offers reliable connection and effective congestion control by adjusting the window size, in wired networks. A look at all the approaches proposing improved transport layer shows two major trends [1]: on the one hand, many protocols try to achieve improvement while maintaining compatibility with TCP. On the other hand, many approaches willingly sacrifice compatibility to gain more freedom and better fit the specific needs of manets.

In wireless network variants of TCP, such as TCP TAHOE, TCP RENO, NEW-RENO, VEGAS etc. are used to control congestion in manets. In his paper M.M. Morshed [2] has simulated the above four TCP variants, and shows that TCP Vegas outperforms the other three TCP variants, showing the highest efficiency.

In paper [3], AODV-Multipath protocol is proposed, which selects a route from source to destination based on the queue length and hop count to avoid congestion in the network. If the queue length crosses a certain threshold value, then alternate paths are used to balance the load.

W.R. Salem and S. Hariharan in [12] focus on congestion avoidance in terms of window size and data rate. Through simulations they conclude that Window based congestion control can resolve congestion efficiently and has higher average throughput than slow start.

In [11] a comparative study of AODV and OLSR for multiple traffic in manets with TCP congestion control has been done. Random waypoint mobility model has been used for different number of nodes for sending multiple traffic in the network. They found that a number of nodes affects the performance of the network and AODV outperforms OLSR.

In [17], the authors have proposed two congestion-aware metrics, BOR and SFSR, to enable routing protocols to consider congestion issues. They have used these metrics to modify DSR to improve throughput of networks. Buffer Occupancy Ratio (BOR) indicates the utilization of the resource available in a node and its ability of packet forward packet (BOR = Occupied buffer size/buffer size). Successful Frame Sending Ratio (SFSR) indicates contention of an area and cost for sending packets through this area (SFSR = Number of received ACKs/number of sent frames). In the proposed scheme once the route is selected, it will not be changed until it is broken.

In [4], a new routing protocol (EDAODV) early detection congestion and control routing protocol for wireless adhoc networks has been presented. It detects congestion by calculating queue status value and finds congestion status (CS) of a node. Based on CS, the non-congested successor and predecessor nodes of a congested node are used to find alternate non congested path bi-directionally between them for data transmission. The simulation study show that EDAODV lost fewer packets than AODV that are not having congestion control mechanism.

T. Senthil Kumaran et al. presents EDCSCA-ODV, an early detection of congestion and self-cure routing protocol for wireless adhoc networks

[5]. This proposed algorithm cures congestion by using local path concept, by periodically calculating the queue status of path nodes, thus detecting congestion likely to happen and send warning message and apply automatic cure algorithm to get alternate path for it. EDCSCAODV improves performance by reducing delay, routing overhead and increasing packet delivery ratio without incurring any significant cost.

In paper [7] a novel method for dynamic congestion detection and control routing (DCDR) based on the estimation of the average queue length at the node level has been proposed. This scheme is based on Congestion Free Set (CFS) to identify a congestion free path to the destination. The drawback of this algorithm is that during heaviest traffic flows it suffers from packet loss and it does not consider the wireless losses.

Bambang et. Al [16], clearly defines transfer reliability and congestion control in opportunistic networks, which are a class of mobile adhoc networks. Open research issues have been identified.

A mobile agent based congestion control[8] AODV protocol is proposed, in which mobile agents collect and update routing information and congestion status of the nodes using the Total Congestion Metric(TMC), thus giving dynamic network topology to nodes.

In [9], Yuang Yi et al. have proposed a hop by hop congestion control algorithm using optimization based framework, with channel access time imposed as a MAC constraint. Using the Lyapunov function-based approach they show that their algorithm is globally stable in the absence of delay. While in the presence of the delay, they proved that the algorithm has the property of spreading through simulations. They have derived bounds on the peak load at a node by hop-by hop count and end-to-end delay, proving hop-by hop scheme to have significant gains.

In [10], CBCC (Cluster Based Congestion Control) consisting of scalable and distributed cluster based mechanism for supporting congestion control in manets have been proposed. This scheme is based on the self-organization of the network into clusters. Within its localized scope the clusters autonomously and proactively monitor congestion.

In paper [13], a study of coding and congestion aware routing protocols have been presented.

Table 1. Summary of congestion control metrics in Manets

Proposal	Congestion Control Strategy	Congestion Control Method	Underlying routing protocol	Performance evaluation/ service target
Early detection of Congestion and Control [4]	Congestion Detection	Drops packet based on queue-status	EDAODV	Packet delivery ratio, End-to-End delay
Early Congestion detection and self-cure routing [5]	Congestion Detection	Drops packet based on periodically calculated queue-status	EDCSAODV	Packet delivery ratio, End-to-End delay
Congestion Adaptive multipath routing [6]	Load balancing	Distributes traffic if average load increases beyond defined threshold and residual battery energy and bandwidth decreases below defined threshold	QMRB	Packet delivery ratio, End-to-End delay, Throughput
Congestion Aware multipath routing with cross layer design [17]	Congestion avoidance	Buffer Occupancy ratio(BOR) and Successful frame sending rate(SFSR) checks congestion status of nodes	MDSR-C	Packet delay, packet loss rate, network throughput
Congestion Avoidance and load balancing using queue length [3]	Congestion Avoidance and load balancing	Queue length and hop count are used to select route	AODV-Multipath	Packet delivery ratio, throughput, average delay, dropped packets
Sufficient Bandwidth aware routing [19]	Congestion Avoidance	Channel free time (CFT) status of nodes checked during route discovery	AODV+SBA	Packet delivery ratio, End-to-End delay, Normalized Routing Overhead
Dynamic Congestion Detection and Control [7]	Congestion Detection and Control	Congestion Free set (CFS) connects one hop and two hop neighbors and identifies a congestion free path	DCDR	Packet delivery ratio, End-to-End delay, routing overhead
Mobile agent based congestion control [8]	Congestion Avoidance	Total Congestion Metric (TCM) obtained using queue length and channel contention	ABCC-AODV	Packet delivery fraction, throughput, average end-to-end delay
Congestion Free Routing metric (proposed)	Congestion avoidance	Resource Free Routing (RFR) considers dynamic buffer size, battery power and bandwidth for route selection	CFAODV	Packet delivery ratio, End-to-End delay, Throughput

This concludes that network coding help exploit unique opportunities offered in the adhoc networks.

Survey of congestion control techniques under manets has been provided by Hitesh Gupta et.al [14], along with a novel proposed approach to control congestion in AOMDV protocol, using queue technique.

In [19], a novel AODV (AODV+SBA) routing protocol has been proposed which improves performance by reducing excessive routing overhead, by using the CFT(Congestion Free Time) metric used in MAC layer.

In survey paper [15], an overview of different congestion control algorithms in manets has been presented. This paper concludes that no single congestion control mechanism is helpful, we need to combine them for efficient results.

Chen et. al [21] have proposed a congestion-aware routing protocol for mobile ad hoc networks (CARM) which uses a metric incorporating data-rate, channel delay, buffer delay, and retransmission count to combat congestion and improve network utilization. The metric used, together with the avoidance of mismatched link data-rate routes, to make ad hoc networks robust and adaptive to congestion.

In paper [22] Seetan and others have proposed a mechanism for congestion-avoidance based on the selection of the least congested routes as they are discovered, instead of the shortest ones. Using simulations, the proposed route discovery algorithms have achieved better packet delivery ratio (up to 11% improvement) as compared with the AODV routing protocol. A source and destination make routing decisions by selecting the least congested route, where the congestion of a route is determined as the total congestion value computed for intermediate nodes, or as the maximum congestion value at the intermediate nodes. Detailed simulations were used to evaluate the performance of the proposed congestion-based routing schemes and to compare them with AODV routing. The simulation results show that the proposed schemes can result in substantial improvement in the packet delivery ratio.

In paper [23], a fuzzy adhoc rate-based congestion control (FARCC) to enhance the efficiency of network in MANETs has been proposed. In FARCC, a rate-based transmission scheme uses two fuzzy controller of zero order Takagi Sugeno Kang (TSK) model to congestion detection and congestion control. The FARCC sender adjusts data rate by receiving a feedback packet from FARCC destination. NS2 implementation results show that FARCC outperforms ITP and ATP to achieve, in terms of throughput and fair resource allocation in Adhoc networks under random topology.

Dr Pujeri and Sheeja [24] proposed to develop the Effective Congestion Avoidance Scheme (ECAS), which consists of congestion monitoring, effective routing establishment and congestion less based routing. The overall congestion status is measured in congestion monitoring. The contention metric in the particular channel in terms of, queue length of packet, overall congestion standard, packet loss rate and packet dropping ratio to monitor the congestion status has been proposed. Based on the congestion standard, the congestion less based routing is established to reduce the packet loss, high overhead, long delay in the network. Simulation studies show that proposed scheme achieves better throughput, packet delivery ratio, low end-to-end delay and overhead than the existing schemes.

PROPOSED WORK

In this paper we propose a new metric RFR (Resource Free Ratio) for congestion control. For effective load balancing the metrics one must capture the load effectively on the network. RFR takes into account the three most important parameters for improving the network performance and reducing congestion in the network. In our approach if a nodes dynamic buffer size, bandwidth and the remaining power is below a defined threshold, then during route discovery such nodes are avoided. In this way not only the node but the congested area is discarded, and hence, the load is balanced equally on the network.

Dynamic buffer size = current occupied buffer/allowed buffer range

We use the mechanism suggested by [6] to calculate the available bandwidth. For the calculation of the bandwidth the idle period of the wireless channel is important. The available bandwidth can be calculated as:

$$BW_{av} = BW_{max}(idle_t/int_t) \qquad (1)$$

where: BW_{max} is the maximum available bandwidth and $idle_t$ is the idle period of the wireless channel over the time interval int_t, where:

$$idle_t = int_t - busy_t. \quad (2)$$

The carrier sense mechanism of IEEE 802.11 can judge whether the wireless channel is idle or busy and can be used to monitor the transition state. The above equations 1 and 2 can be used to calculate the bandwidth of the wireless link.

Estimation of battery power

The battery power consumed by a node after time t can be calculated as [6]

$$E_c(t) = \sigma \cdot N_T + \rho \cdot N_R \quad (3)$$

where: N_T – number of data packets transmitted by the node after time t;

N_R – number of data packets received after time t;

ρ, σ – constants having values between 0 and 1.

If E_1 is the initial power of the node, then the remaining power of the node E_R at time t can be calculated as:

$$E_R(t) = E_c(t) - E_1 \quad (4)$$

Calculation of RFR

During calculation of RFR all the three parameters ratio must be above the threshold value to select the node for communication.

- Initially estimate Dynamic buffer size
  If DBS> threshold
- Next estimate available bandwidth
  If BW> threshold,
- Then finally calculate the battery power.
  If BP> threshold,
- Now RFR=Avg (DBS + BW + BP)
  If RFR> threshold
- Then select the node
- Else drop the node.

Proposed algorithm

During route discovery phase:
1. Initiate RREQ packet by setting RFR
2. Broadcast the RREQ packet
3. At intermediate node
   If (RFR<threshold)
       Drop node
   Else If (any intermediate or destination node has up-to-date route)
       Send RREP packet to source
   Else
   Update RREQ packet and rebroadcast it to its neighbors.

This metric will find the least congested node and balances the load throughout the network equally.

RESULTS USING FUZZY LOGIC

Mat lab has been used for designing the fuzzy logic system, using which we have calculated the chances of a node to be selected or dropped. For this purpose we have coded 27 rules and taken following parameters:
1. Fuzzy Input parameter: DBS, BW, BP.
2. Fuzzy Output parameter: Probability function.

According to our proposed algorithm, we have input these three parameters into the fuzzy system which produces output probability function. This output probability function gives us the probability of a node to be selected or dropped. We have taken a fixed threshold range. More the summation value of dynamic buffer size(DBS), Bandwidth(BW), Battery Power(BP) is greater than threshold range, more will be the value of probability function and hence more the chance of
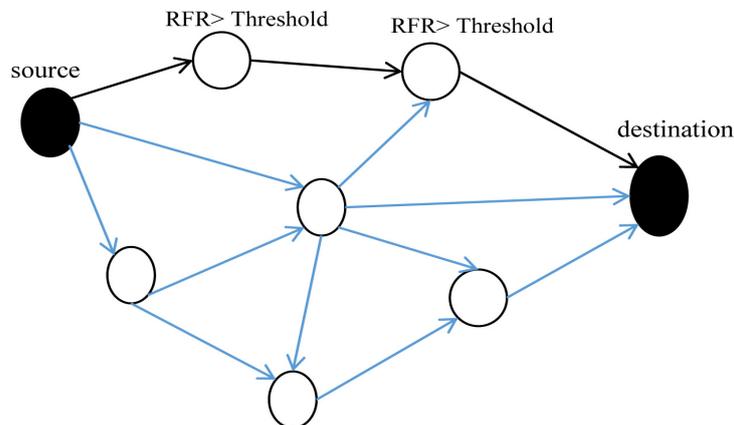

Fig. 2. Route discovery using RFR

a node to be selected otherwise it will be dropped.

$$\text{Probability } (x_i) \propto \sum ((DBS) + (BW) + (BP)) \, x_i \quad (5)$$

The above equation clearly shows the probability of a node (*x*) is directly proportional to the summation value of three parameters. Fuzzy logic system, named by metric proposed for congestion control that is RFR (Resource Free Ratio) is shown in Figure 3. Here, three fuzzy variable are input and the required output is probability produced.

Membership function of Dynamic Buffer Size (DBS) is shown in Figure 4. Here membership function plot are shown corresponding to threshold range.

Output probability function curve is divided into various regions namely VSmall, Small, RSmall, Medium, RHigh, High, VHigh are shown with the help of Figure 5.

Figure 6 have shown the results regarding the amount of probability value produced. Input value for DBS, BW, BP are taken as 50, 50, 50 respectively which produces probability of 90.8, which lies in VHigh range.

Relationship between Bandwidth (BW), Battery Power(BP) and Probability output is also shown in surface viewer in Figure 7. Here *X* axis corresponds to Bandwidth (BW), *Y* axis corresponds to Battery power (BP) and *Z* axis corresponds to probability of node to be selected or dropped.
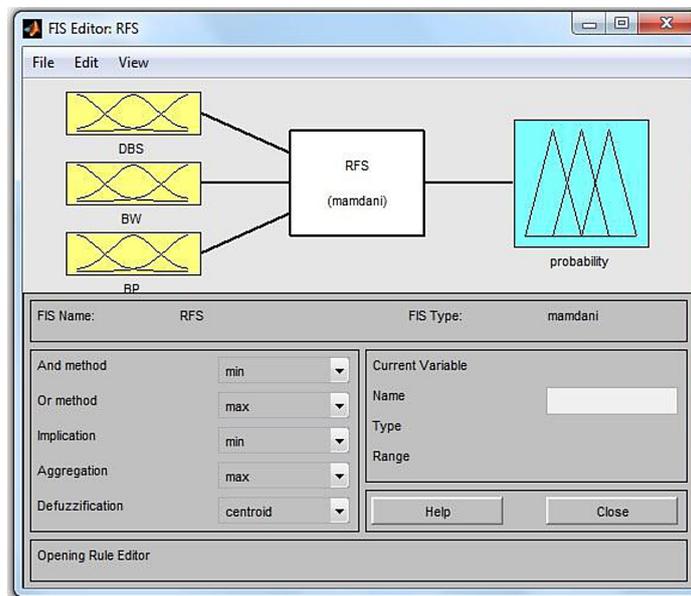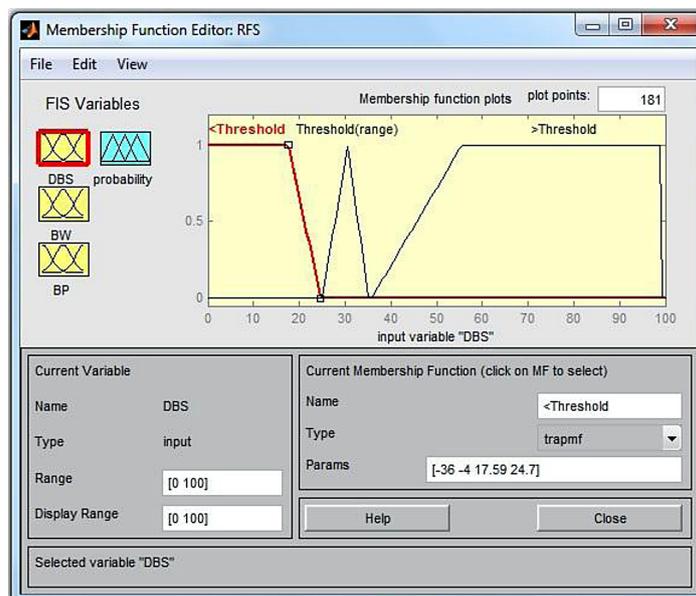

Fig. 3. Fuzzy logic system
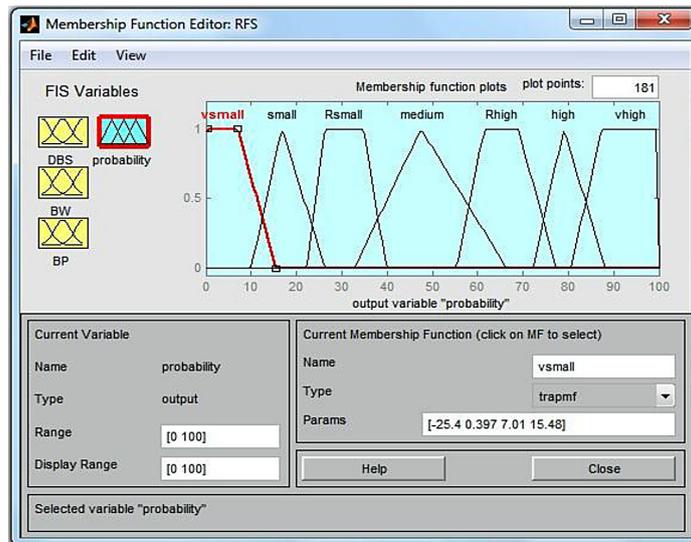

Fig. 4. Membership function of DBS variable

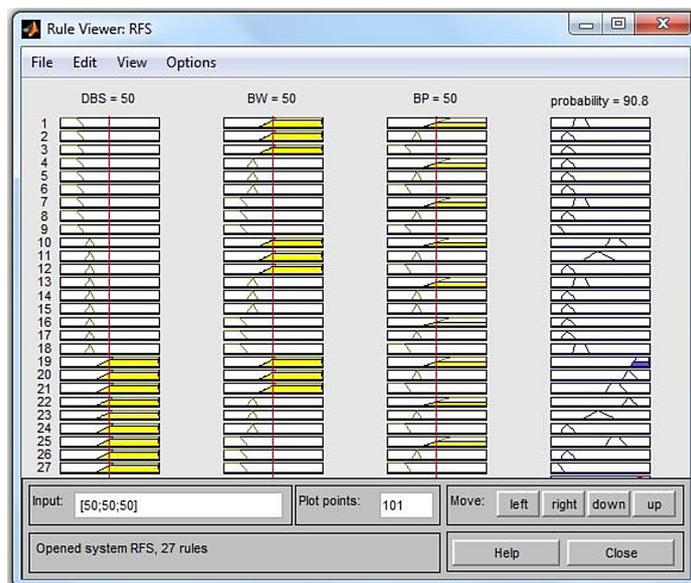**Fig. 5** Membership function of output probability variable
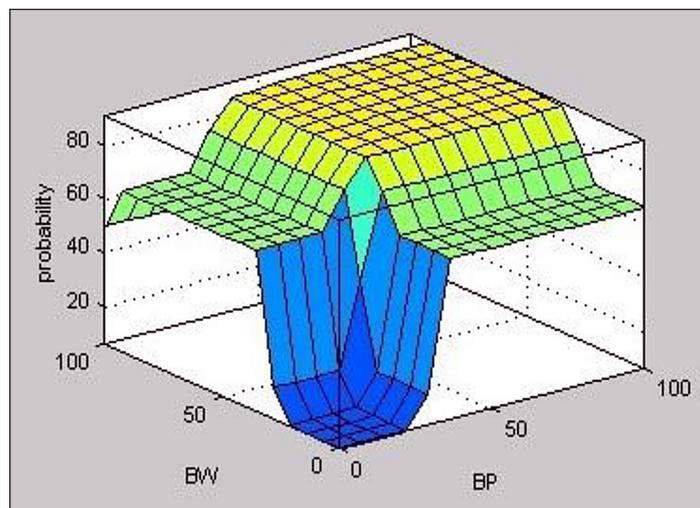

Fig. 6. Fuzzy rule view

Fig. 7. Surface Viewer

CONCLUSION

In this paper we have given an overview of almost all congestion control techniques used in mobile adhoc networks. Congestion in adhoc networks can be controlled either through routing or using the standard TCP congestion control mechanisms used in wired networks with modification and compatibility for wireless networks. Due to high node mobility and topology changes, the TCP control techniques applied to adhoc networks are inadequate to handle congestion. The congestion control metrics have been studied in detail. We further conclude that the available congestion control mechanisms and metrics are not sufficient and do not reduce packet loss down to a substantial level. Here we have proposed a metric RFR which works on the three important parameters to discover a congestion free route and balances the load on the network.

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