Multicasting Within Mobile Ad hoc Networks

J.P. Macker, R.B. Adamson, J. Dean, W. Chao,
I.T. Downard, J.W. Weston, and R.D. Lee
Information Technology Division

Background and Problem Area: The development of mobile ad hoc networking (MANET) technology for DoD use presents formidable challenges.[1] The Naval Research Laboratory (NRL) has been a technology leader in the conception, development, and standardization of MANET technologies. MANET technology is evolving and will allow future DoD network systems to self-organize and operate more autonomously without reliance upon a fixed infrastructure. Despite recent advances in this technology, there remains little work in adapting or standardizing multicasting forwarding in MANET.[2] Multicasting provides efficient network group communications, a feature important in future DoD tactical edge and network-centric scenarios. This article briefly describes recent NRL work advancing the state of the art in multicast forwarding capabilities for MANETs.

A Simplified Multicasting Process for MANETs: Previous research in MANET technology has developed techniques for optimizing the process of flooding control information often applied to specific routing protocol designs and requirements.[3] There is recent interest in applying these techniques to forward multicast user data in mobile, wireless data networks. Within MANETs, a simpler multicast forwarding model that optimizes the forwarding of multicast traffic to all participating nodes in a routing area is often useful. One such solution is the Simplified Multicast Forwarding (SMF)[4] specification design within the Internet Engineering Task Force (IETF). SMF is a flexible common framework for MANET multicast forwarding independent of any unicast routing specification. It includes a duplicate packet detection mechanism and supports multiple forwarding optimization methods. A recognized research challenge has been to better characterize the traffic loading performance of various algorithms within multicast mobile wireless networks.

CDS Algorithm Improvement: Algorithms that help form and minimize a Connected Dominating Set (CDS) are often considered as design frameworks for MANET multicast forwarding to minimize forwarding relay sets. Figure 4(a) represents a wireless network of 100 nodes and the related topological links between the nodes. Classical flooding (CF) or legacy wireless forwarding algorithms use all red nodes in Fig. 4(a) to retransmit network packets at least once, leading to the well-known broadcast storm problem.[5] To illustrate the value of CDS algorithms, Fig. 4(b) shows a connected graph containing only a subset of the total links and relay nodes obtained using a distributed CDS algorithm. The smaller number of red relay nodes (i.e., 12 vs 100) clearly demonstrates a significant reduction in the relay set size required to reach all destinations vs the CF approach.

Our research goes beyond CDS efficiency analysis predicted from static graphs, as illustrated in Fig. 4. We are developing operational models and exploring the robustness of multiple techniques under emulated and simulated mobile, wireless network conditions. Figure 5 is a sample of a simulation analysis comparing several CDS algorithms against CF within an increasingly congested mobile network. As shown in Fig. 5, CDS algorithms can improve network goodput (i.e., usable received network data) over CF as load increases. Due to inefficient relaying, the CF algorithm causes network contention and congestion under lighter source traffic loading than more optimized CDS algorithms.

Summary: NRL research is characterizing the complex behavior of various distributed relay set algorithms being considered for future MANET multicast forwarding. NRL also acts as a technical leader in a related Internet protocol standardization process and is transitioning lessons learned from this research within that forum. Research products are also expected to aid in supporting the complex design tradeoffs needed in developing future tactical Navy and DoD mobile wireless networks. Future plans include extending this work by researching the performance of reliable multicast transport mechanisms within SMF-enabled MANET models.

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References

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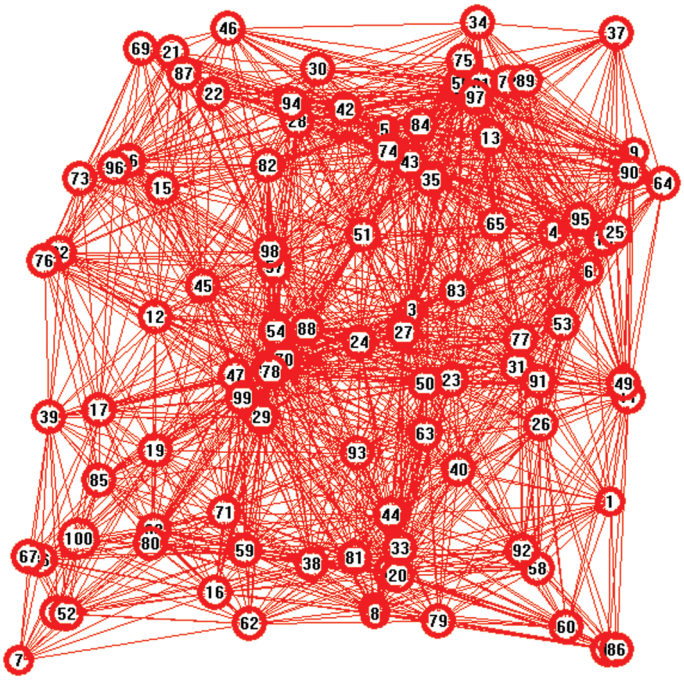
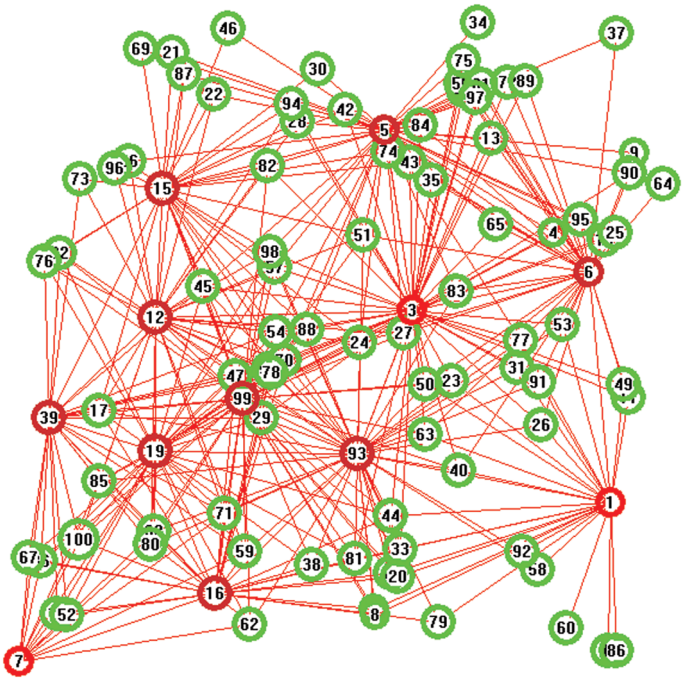


(a)



(b)

FIGURE 4
(a) 100-node network (fully connected no CDS) and (b) 100-node network (MPR-based CDS algorithm).

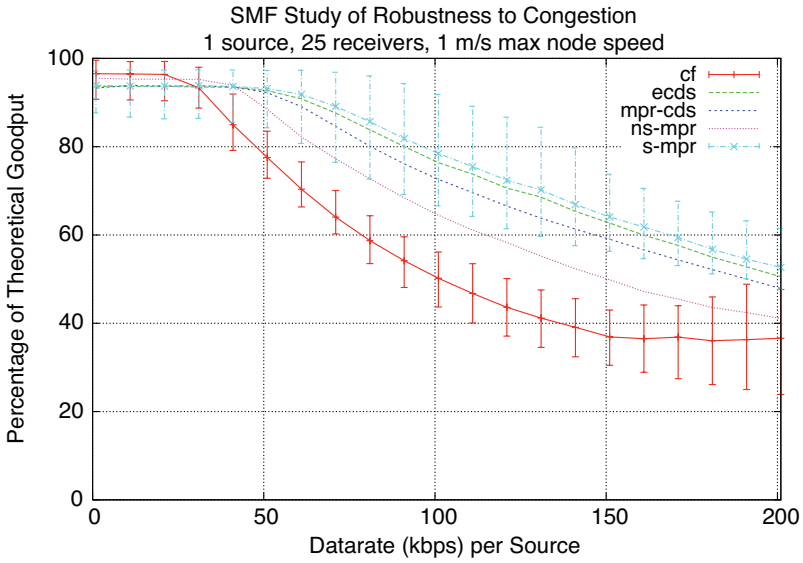


FIGURE 5
CDS algorithm study with mobility and increasing traffic volume.