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# Smart data packet ad hoc routing protocol

Saman Hameed Amin *, H.S. Al-Raweshidy, Rafed Sabbar Abbas

*Wireless Network and Communications Centre (WNCC), Electronic & Computer Engineering, School of Engineering and Design, Brunel University, London, UK*

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ABSTRACT

This paper introduces a smart data packet routing protocol (SMART) based on swarm technology for mobile ad hoc networks. The main challenge facing a routing protocol is to cope with the dynamic environment of mobile ad hoc networks. The problem of finding best route between communication end points in such networks is an NP problem. Swarm algorithm is one of the methods used solve such a problem. However, copping with the dynamic environment will demand the use of a lot of training iterations. We present a new infrastructure where data packets are smart enough to guide themselves through best available route in the network. This approach uses distributed swarm learning approach which will minimize convergence time by using smart data packets. This will decrease the number of control packets in the network as well as it provides continues learning which in turn provides better reaction to changes in the network environment. The learning information is distributed throughout the nodes of the network. This information can be used and updated by successive packets in order to maintain and find better routes. This protocol is a hybrid Ant Colony Optimization (ACO) and river formation dynamics (RFD) swarm algorithms protocol. ACO is used to set up multi-path routes to destination at the initialization, while RFD mainly used as a base algorithm for the routing protocol. RFD offers many advantages toward implementing this approach. The main two reasons of using RFD are the small amount of information that required to be added to the packets (12 bytes in our approach) and the main idea of the RFD algorithm which is based on one kind of agent called drop that moves from source to destination only. This will eliminate the need of feedback packets to update the network and offers a suitable solution to change data packet into smart packets. Simulation results shows improvement in the throughput and reduction in end to end delay and jitter compared to AODV and AntHocNet protocols.



## 1. Introduction

The absence of infrastructure in mobile ad hoc network (MANET) and the dynamic and continuously changing network topology compose real challenges to routing algorithms [1]. Routing in such a network is considered as an optimization process of locating the optimal paths between sources and destinations. A number of algorithms have been proposed to address routing in ad hoc networks [2–6].

Routing protocols for mobile ad hoc can be generally classified into three types. Firstly, proactive routing protocols, which also can be called as table-driven routing protocols, such as Optimized Link State Routing protocol (OLSR) [7], and Destination-Sequenced Distance Vector (DSDV) routing protocol [8]. Secondly, reactive routing protocols, which also can be called as on-demand routing protocols, such as Ad hoc On Demand Distance Vector (AODV) routing protocol [9], and Dynamic Source Routing (DSR) protocol [10]. Finally, hybrid routing protocols such as Zone Routing Protocol (ZRP) [11], and Hybrid On-demand Distance Vector Multi-path (HODVM) routing protocol [12].

* Corresponding author. Tel.: +44 7543386452.
*E-mail address:* saman.amin@brunel.ac.uk (S.H. Amin).

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Swarm intelligence (SI) has widely been used to address the problem of finding optimal routes [5]. Cognitive Packet Network (CPN) is another approach to solve routing problem which is based on on-line sensing and monitoring of network Quality of Service (QoS) [13].

Designing a protocol with two or more QoS constraints is known to be a NP-complete problem [14]. As problem size increases, the computational complexity of a problem increases, and more time and computation power are required to solve such a problem. Accordingly, finding shortest path as well as minimizing delay and avoid congested nodes is an NP-complete problem. Swarm intelligence has been adapted to solve routing problems due to their efficiency and distributed approach. However, to solve complex problem using swarm algorithms, the number of iterations required will be proportional to problem complexity. As the network become more dynamic, the topology will change faster, and more swarm agents are needed to cope and quickly adapt with this changes in the network. In highly dynamic environment, more agents are required to detect link qualities in order to find best route. Increasing the rate of agent, in order to quickly adapt to the changes, will consume more resources. Moreover, each agent will require a feedback agent to adapt learned parameters which will increase resource consumption.

This paper will propose a smart data packet protocol for mobile ad hoc network using RFD and ACO algorithms. While the main idea is based on the RFD algorithm, ACO algorithm is used to address the bottleneck of slow convergence rate of the RFD algorithm in the starting of learning procedure [15]. The using of ACO algorithm will build a multipath route from source to destination at the beginning of route setup. We introduce the use of data packet in the learning process of swarm algorithm. Rather than increasing the number of agents, we use data packets which act like drop agents. We call these packets "smart data packets" because they behave in smart way by avoiding congested nodes and they incorporate in the learning process. Moreover, we call them smart to distinguish them from ordinary packets (packets that are not acting like drops). As these data packet moves in the network, they adapt altitude tables, and the network learn about its environment. Using smart data packet will accelerate the sensing and reaction toward network parameters change.

ACO has been widely used for solving routing problem. In general, in ant based routing protocol, a node generate forward ant packets to find the destination. Ant packets move around the network in a random walk to find the destination. This movement is based on some stochastic probability function. When the destination is found, a backward ant is send from the destination toward the source. As the backward ants move back to the source, they update the pheromone intensity on the links between the nodes. The path with higher pheromone intensity will attract more ants and data packets. After a period of time, the optimal route, depending on the optimization parameters, will be become attractive and will be chosen by the data packets.

River formation dynamics is a subset of swarm intelligence. It reflects how raindrops on highlands join together to form rivers [16]. These rivers tend to take shortest path to the sea. Implementing the RFD algorithm in ad hoc routing protocols provides many advantages. First of all, as there is no backward agent in the RFD algorithm, it will decrease the total number of control packets in the network. Another advantage is the simplicity of the algorithm; especially it relates altitudes to nodes rather than links. As generally the number of nodes is usually less than the number of links in a network. This minimizes the resource usage. More advantages comes from the fact that the implemented RFD based protocols are using promiscuous communication mode, so the learning process is not local but all neighbor will be affected by the learning process. As drops are moving in the network, they update the altitude of the nodes. The drop carries recent node altitude which will be detected by neighboring nodes. All neighbor nodes will update the corresponding node altitude in their tables. In other words, one change in a node's altitude which announced by one drop packet is corresponding to changes of all links between that node and all its neighbors. A farther advantage is since RFD uses just drops, which element the need for backward agents and RFD drops adapts network parameters while they are moving from source(s) to destination(s), this will offer the opportunity to use data packets and make them act like drops. This allows data packets to guide themselves and contribute in the learning process. Other protocols usually require backward agents to adapt routing parameters. With other protocol, assigning a backward agent for each data packet will exhaust the network. Finally, the amount of control information appended to data packets is small, which make it easy to integrate the information into the data packets.

This paper is organized as follows. In the next section, related works are given briefly. Section 3 will explain the main idea of the RFD algorithm. Section 4 will explain the proposed protocol. The results and implementation are given in Section 5. Finally, a conclusion is given in Section 6.

## 2. Related works

Routing algorithm is an optimization process that tries to maximize network performance while minimizing costs. In [9] AODV introduced to solve routing problem. AODV is one of the most popular classical routing protocols for mobile ad hoc networks. Whenever a node needs to send data to a destination, and it does not have the valid route to destination, it broadcast a Route Request (RREQ) message to find the destination. Upon receiving RREQ, Route Replay (RREP) message is send back to the source. AODV in its original form uses hello message to periodically update its neighbor nodes availability. Link breakage could be detected if unsuccessful packet transmission occurs or missing hello message. In case of link failure the node send back a Route Error (RERR) to the source in order to search for new route. DSR [10] is another type of on demand ad hoc routing protocol which uses dynamic source routing. Unlike hop to hop routing, source routing protocol adds the complete route path to the packet which gives the source node complete control on how the packet moves in the network. Ad hoc On demand Multipath Distance Vector