Situation-Aware QoS Routing Algorithm for Vehicular Ad Hoc Networks

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***Abstract*—A wide range of services has been developed for vehicular ad hoc networks (VANETs), ranging from safety to infotainment applications. An essential requirement for such services is that they are offered with quality of service (QoS) guarantees in terms of service reliability and availability. Searching for feasible routes subject to multiple QoS constraints is, in general, an NP-hard problem. Moreover, routing reliability needs to be paid special attention as communication links frequently break in VANETs. In this paper, we propose employing the situational awareness (SA) concept and an ant colony system (ACS)-based algorithm to develop a situation-aware multiconstrained QoS (SAMQ) routing algorithm for VANETs. SAMQ aims to compute feasible routes between the communicating vehicles subject to multiple QoS constraints and pick the best computed route, if such a route exists. To mitigate the risks inherited from selecting the best computed route that may turn out to fail at any moment, SAMQ utilizes the SA levels and ACS mechanisms to prepare certain countermeasures with the aim of assuring a reliable data transmission. Simulation results demonstrate that SAMQ is capable of achieving a reliable data transmission, as compared with the existing QoS routing algorithms, even when the network topology is highly dynamic.**

***Index Terms*—Ant colony system (ACS), quality of service (QoS) routing, situational awareness (SA), vehicular ad hoc networks (VANETs), vehicular networks.**

I. Introduction

RECENTLY, the development of vehicular ad hoc networks (VANETs) has received more attention and research efforts from the industry and academic community [1]–[3]. VANETs are a key technology in intelligent transportation systems that are envisaged to play a significant role in the futuristic smart cities by improving road safety and providing innovative services relating to traffic management and infotainment applications. This has stimulated the creation of a wide range of services for future deployment in VANETs, ranging from safety and traffic management to commercial applications [4]. These services must be offered with quality of service (QoS) guarantees. Otherwise, they will not be successfully deployed or used. The highly dynamic nature of VANETs makes the resource reservation for the services not applicable to providing QoS guarantees. Moreover, the communication link between two vehicles is vulnerable to disconnection due to the vehicular movements and the unpredictable behavior of drivers. These make the QoS metrics associated with the current established routes change rapidly, and the selected best computed route could quickly become inefficient or even infeasible. Therefore, picking the best computed route cannot guarantee reliable data transmission, even if it satisfies the defined QoS constraints when it is established. This problem is the subject of this paper.

Searching for feasible routes in a multihop vehicular network subject to multiple QoS constraints features a multiconstrained path (MCP) selection, which is proven to be an NP-hard problem [5] if the constraints are mutually independent [6]. Considerable work has been conducted to address QoS routing and MCP problems in stable networks (see [7]–[13]). Generally, there are two distinct approaches adopted to solve MCP problems, namely, exact QoS routing algorithms and heuristic and approximation routing algorithms. In these two approaches, different strategies have been followed, such as the nonlinear definition of the path length [14], lookahead feature [15], nondominated paths [16], Dijkstra-like path search [17], and k-shortest path [18]. Distributed heuristic solutions such as swarm-intelligence-based algorithms display several features that make them particularly suitable for solving MCP problems in VANETs. They are fully distributed; hence, there is no single point of failure; they are self-organizing and, thus, robust and fault tolerant; and they intrinsically adapt to traffic changes without requiring complex mechanisms [19]. The ant colony system (ACS) has been recognized as an effective technique for producing results for MCP problems that are very close to those of the best performing algorithms [20]. However, how and, in particular, to what degree the ACS mechanisms can contribute toward a situation-aware multiconstrained QoS (SAMQ) routing in VANETs is still unresolved.

In general, situational awareness (SA) is the ability to extract information from the environment, integrate that information with relevant internal knowledge, and use the resulting mental picture to anticipate future events [21]. It describes the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, the projection of their status in the near future, and the possible countermeasures that can be taken to manage the risks associated with decisions made based on the projection [22], [23]. In this context, a multiconstrained QoS routing process in VANETs can be considered from an SA perspective.

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