Vehicular Data Analytics Dew Computing

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Abstract— **Recent development of Intelligent Transportation System (ITS) offer several technologies. In centralized ITS solutions, such as Google map, crowd sourcing app Waze, Toyotas Entune dynamic routing, on board smart phone devices or vehicles send periodic local traffic data to a central server or cloud, and receive periodic traffic statistics on their routes of interest. The decentralized ITS solutions use Vehicular Ad Hoc Networks (VANET) to collect traffic information through vehicle-to-infrastructure (V2I) communication and vehicle-to-vehicle (V2V) communication. Cloud is a bottleneck in areas where Internet access may be limited. In this paper, we propose to develop a traffic aware routing algorithm on dew computers.**

I. INTRODUCTION

Real-word applications are complex networks, which can be represented abstractly as graphs. System entities in these scientific problems are the graph nodes and inter-relationship between these entities are the graph edges. The focus of this research is on one complex network, transportation networks.

Finding the optimal travel path from a source to destination on a given road map is called the vehicle routing problem. The road map is usually represented as a graph.The entities in transportation networks are landmarks, junctions or intersections and the links are the roads or lanes between these entities. In classical algorithms such as Dijkstras algorithm [1] and A* algorithm [2], the vehicle routing problem is solved by finding the shortest path on the road map with the weight on an edge representing the actual geometric distance between two junctions. These classical routing algorithms are static and do not consider the dynamic traffic information such as congestion, accidents and road closure. As vehicle traffic congestion becomes alarming severe in modern metropolitan areas, traffic-aware vehicle routing is one of the most important problems in improving quality of life and building smart cities with higher productivity, less air pollution and less fuel consumption. Recent development in Intelligent Transportation System (ITS)[3] offer several technologies.

In centralized ITS solutions, such as Google map, crowd sourcing app Waze, Toyotas Entune dynamic routing, on board smart phone devices or vehicles send periodic local traffic data to a central server or Cloud, and receive periodic traffic statistics on their routes of interest. The centralized ITS solutions are simple to implement and generally have good optimality due to the availability of global traffic information and powerful central computing power. However, such solutions require constant cellular connectivity of the smart phones or vehicles, and have a single point of failure on the centralized computing platform.

The decentralized ITS solutions use Vehicular Ad hoc Networks (VANET) to collect traffic information through vehicle-to-infrastructure (V2I) communication and vehicle-to-vehicle (V2V) communication. VANETs use IEEE 802.11p standard, an amendment to the IEEE 802.11 (Wi-Fi) standard, for dedicated short range communication (DSRC). In V2I communication, vehicles exchange information about specific road segment with nearby Road Side Units (RSU) via continuous wireless communication such as Wi-Fi hotspots or long/wide range wireless technologies. In V2V communication, vehicles are connected to nearby vehicles using short range wireless technologies. Compared to the centralized ITS solutions, VANETs are highly distributive and have lower cost for cellular bandwidth usage. Compared to cellular communication systems that only exist in some newer vehicles, embedded V2I/V2V communication systems are more prevalent in existing and new vehicles. Effective V2V communication is also much more economical than V2I communication, which requires the installation of RSUs and therefore investment in city infrastructure.

There are advantages and disadvantages of both V2I and V2V communication. The technology for V2I communication is well developed compared to V2V communication. However, V2V communication is a decentralized approach that can collect information in real time during a vehicle's movement on the road. The lack of technology to implement a decentralized environment is the main bottleneck in V2V communication. The proposed solution is to develop a traffic aware routing algorithm using dew computers.

II. RELATED WORK

There are two main challenges for dynamic real-time traffic-aware vehicle routing using V2V communication: 1) how to collect real-time traffic data, and 2) how to dynamically route a vehicle based on real-time traffic data as the vehicle travels on the road.

Collection of real-time traffic data requires efficient routing of data packet from vehicles to vehicles. In V2V communication, the connectivity between two vehicles is called a link. Due to the highly dynamic nature of vehicle mobility, and complex road condition and building blockage, VANETs are characterized by highly dynamic topologies with frequent link breakages, network fragmentation, and a high number of packet collisions and interferences. Therefore, studies of VANET protocols [4], [5], [6] have mainly focused on evaluating Quality of Service in delivery of arbitrary data packets

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from a source vehicle to a destination vehicle. However, the collection of traffic data requires generally involves multiple sources (the vehicles on the route of interest sending traffic data) and one destination (the vehicle requesting traffic data), which adds to number of hops and latency. Giuseppe, et al.[7] propose four V2V protocols for traffic congestion discovery along routes of interest through beacon messages.

After the collection of real-time traffic data, the next challenge is how to incorporate it into dynamic vehicle routing. In addition to improvements in traditional algorithms [8], [9], stochastic algorithms mimicking the routing of social animals in the dynamic nature have attracted much attention due to their proven efficiency and similarity to the dynamic vehicle routing problem. One popular algorithm is Ant Colony Optimization (ACO) [10], an iterative and evolving optimization heuristic. In nature, ants explore routes from nest to food source and deposit a chemical substance called pheromone, which attracts other ants to follow the same route. Pheromones evaporate over time. Eventually the longer paths lose pheromone concentration and all ants travel on the shortest path. For dynamic routing, Zhe et al. [11] develop a variant of ACO algorithm that uses stench pheromone to redirect ants to the second best route if the best route becomes too crowded. The authors incorporate traffic to the cost of each road segment as the total travel time on the segment. Jos Capela, et al [12] propose a hybrid algorithm of the Dijkstras algorithm and inverted ACO for traffic routing. These algorithms are centralized solutions that require global knowledge of the dynamic road network. In [13], the authors proposes efficient GSR, an improvement of the geographical source routing (GSR) protocol[6] using small controlled packets called ants to communicate traffic information and Dijkstra to recompute routes. This paper presents a methodology that incorporates traffic information in message communication routing for VANET, rather than actual vehicle routing. A communication route with optimum network connectivity is usually a road route with more traffic. In addition, the re-computation using Dijkstra's algorithm is expensive. In [15] we propose a local aware hybrid routing algorithm. In this algorithm, the VANET is divided into zones [14]. Each zone proactively determines the routing within its zone and reactively finds the routing paths within zones. The algorithm is robust to link failures and is scalable.

III. Proposed Solution

In this section we propose a solution that avoids using the Cloud or personal computers for data processing. The computations will be done on a dew computer. Each vehicle, now-a-days is equipped with lots of technological devices for performing many different functions such as heated seats, backup cameras, cruise control, key less entry, navigation, smart phone integration, automatic emergency braking and so on. In the next five years, we predict that chips with multiple processors will be installed on vehicles as they are on smart phones.

Drivers use GPS to navigate their route. The path finding algorithm is currently executed on Cloud and the information is sent directly to the vehicle. Sensors on road side units collect the necessary data to make accurate prediction of the route. The traditional path finding algorithms [1], [2] find only one path. The problem that may occur is the disruption of Internet services which will hinder in finding the route through Cloud. In the proposed solution, the routing algorithm finds multiple paths. We assume that there is a small and simple dew computer installed on each vehicle. These days graphic processors are cheap. Each dew computer will have a graphic processor installed to perform the computations.

The multiple path finding algorithm that we propose to use is the ant colony optimization algorithm. As per our previous work [15], we divide VANET into zones.The vehicles within the zone communicate with each other through short range communication medium. The vehicles exchange information about traffic conditions on the road. Using this information, the ant colony optimization algorithm is run on the road network.

Ant Colony Optimization is inspired by the foraging behaviour of ants searching for food. In nature, ants leave pheromone trails for the other members of the colony to follow their routes from nest to food source. The pheromones evaporate over time. As more ants travel a given path, the intensity of the pheromone increases. This leads to a better route and a shorter route.

The algorithm works in an iterative fashion. Initially, all the routes between source and destination are initialized with the same amount of artificial pheromone. In each iteration, two steps are performed: solution construction and pheromone update. In the phase of solution construction, virtual ants are scattered on the roads. Each ant follows a stochastic rule to choose the next intersection to visit, using a probability function that favors shorter tour and strong pheromone level. The phase ends when each ant completes finding the paths from source to destination. In the phase of pheromone update, pheromone level on all the routes evaporates (decreases) followed by an increment on the shortest tour in the iteration. The pheromone serves as a global memory, or an exploitation, to reinforce the local optimal. The stochastic rule allows ants to find multiple different solutions on several iterations and gives the algorithm enough exploration to find possibly better solutions.

The data collected through V2V and V2I communication mechanisms will serve as a basis for the routing algorithm. The ant colony optimization algorithm is highly parallelizable [16]. The algorithm can be easily parallelized on a graphic processor [17]. In our proposed scheme we will implement the ant colony optimization algorithm on the given road network on a vehicle's dew computer. The computer comprises of graphic processing units that will parallelize the algorithm and provide efficient routes in real time.

IV. Conclusion

The focus of this research is on intelligent transportation system. Predicting a route in the event of traffic congestion or other events on the road is challenging. Currently, Cloud infrastructure is used to perform the routing computations. In this research, we propose to remove the Cloud infrastructure and perform the routing algorithm on dew computers installed on vehicles. We propose to develop a multi-path finding algorithm using a meta-heuristic inspired by real ants in nature.

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