An Emergent Traffic Messaging Service Using Wireless Technology

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Abstract. Real-time information about traffic flow, accidents, or road availability is very important for drivers, and it is useful to implement a messaging system for supporting inter-vehicular communication. Aided by positioning instruments and *ad hoc* network, important messages can be sent from vehicle to vehicle to regulate traffic flow, enhance driving safety and distribute alert messages. We identified various types of broadcasting and analyzed the circumstances for broadcasting. The usefulness of broadcasting was considered in which a message about an accident is important for vehicles approaching the accident, and the information that an ambulance is coming is also important for vehicles before the ambulance. LAN and 3G provide a communication platform for messaging. Broadcasting, P2P communication and SMS are a choice for the messaging system. A prototype of the system was implemented and its application was discussed as well.

Keywords: VANET, GPS, Risk Management, Messaging Service.

1 Introduction

Vehicle Management System is an integration of global positioning system (GPS), geographic information system (GIS), mobile communication system and Internet technology, offering users valuable, real-time information. With a GPS-equipped vehicle, important information like current location, speed, direction, vehicle condition, etc. is sent to the control center. The manager is able to know oil consumption, personnel in vehicle, goods delivery, and anomalous state of the vehicle, and to make right decisions to enhance performance. A vehicle management system can:

(1) Organization of the caravan: update the state of the caravan and the personnel;
(2) Real-time monitoring: control the vehicle based on the latest information, including the condition of the vehicle;
(3) Retrieval of historic data: check the current and historical operation data;
(4) Statistics: provides several statistical reports including transportation fee, overspeed records, oil consumption, mileage, etc.
(5) Vehicle positioning: facilitate query by street, milestone, administrative area and other geographical conditions;
(6) Instant messaging: broadcast message to vehicles using general mode and group mode:
(7) Presentation of vehicle states: present the current condition of a specified vehicle.

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Some industries like taxis require high flexibility to offer high-quality service. Taxi drivers shuffle either in downtown or in countryside to offer fast service to customers. To know the traffic flow and accidents is of great importance for them. Currently, they rely on pagers to share information within the caravan. But this simple equipment cannot meet the requirements of advanced management. The main problem is that it cannot distribute detailed information, coverage of the pager system, exactness of information like location. In this study, we will propose a novel communication system for caravans with vehicles equipped with handset to facilitate inter-vehicular communication.

In an *ad hoc* network, broadcasting is used to distribute information such as emergency, actual traffic flow, business decisions, even entertainment materials. Though simple pager system can afford to distribute information within the caravan, it has several drawbacks like noise, interception, narrow bandwidth, etc. With the development of mobile techniques and smart handheld equipment, better communication service can be offered.

There are three different types of vehicle *ad hoc* network (VANET): inter-vehicle communication (IVC), roadside-to-vehicle communication (RVC) and hybrid-vehicle communication (HVC). Management modes of VANET can be centralized or distributed. In this study, HVC is considered. IVC is used when all vehicles concentrate in a closed area. RVC is used when vehicles are far away from each other. This will increase the reliability of the entire system. Furthermore, as vehicles undergo rapid locative change, we adopt a distributed management mode, so a restructuring of the vehicles group is not necessary.

In instant point-to-point messaging, each site is both a server and a client. As shown in Fig. 1, all vehicles can communicate with each other; failure of any site will not corrupt the network. Managing a taxi caravan, the server can be the management center.

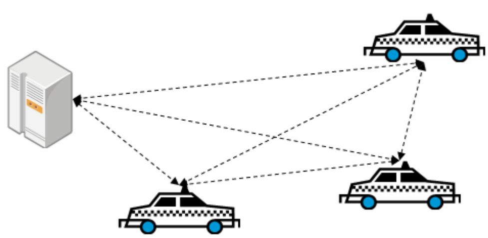

Fig. 1. A fully-connected communication network

This study, proposing a framework to facilitate inter-vehicular communication based on broadcast protocol, aims to reduce broadcasting storms, reduce repeated broadcast, and determine transfer destination. Section 2 is literature review, in which the reason of selecting P2P is explained. Section 3 describes the proposed framework. Section 4 presents the system prototype. And the final section is conclusion.

2 Literature Review

Along with the development of mobile technology, wireless communication network based on the protocol of IEEE 802.11x has become a new alternative for supporting intelligent transportation system (ITS). The P2P communication system forms a distributed framework in which connected nodes sharing a common topic constitute a network without intermediary or server.

According to IEEE 802.11 DCF (Distributed Coordination Function), types of broadcasting can be centralized or distributed. In order to improve the distributed system, we may put some vehicles in groups and appoint a node as coordinator to manage the channel. There are four types of broadcasting: simple flooding, probability-based broadcasting, counter-based broadcasting, and location-based broadcasting [2].

Researchers have proposed various ways for broadcasting. They distinguish among dense traffic regime, carry forward, retry and carry forward [5]. A decision tree can be constructed for DV-CAST in well-connected, sparsely-connected and totally disconnected network [4]. We distinguish between dense traffic, sparse traffic, and regular traffic.

In case of emergency, it is important to inform the vehicles coming from the opposite direction. Targeted routing of the message is of great importance. For instance, information of accident is needed by the vehicles coming behind the site of the accident while the information that an ambulance is approaching is important for vehicles before the accident. Broadcast direction has great impact on the network efficiency [7]. The coordinate system and broadcast direction can be used to classify emergency information to determine where to broadcast. It enhances the applicability of the system [3].

In order to reduce the probability of sending the same message, There are three kinds of broadcasting: weighted *p*-persistence broadcasting, slotted 1-persistence broadcasting, and slotted *p*-persistence broadcasting [6]. These methods are able to reduce redundant packets or avoid loss of packets, but position information is occasionally needed. Besides the position information, local traffic situation is needed as well on the highway or in the city. It is impossible to forward any message if no neighboring nodes are available in an area.

3 The Model

In order to provide the vehicles with necessary information, we propose a real-time, distributed decision-support system for two purposes: one is management, aiming to offer the caravan an information platform to convey real-time information; another is communication, aiming to control the channel and minimize repeated sending. For better understanding, we illustrate it with the aid of two scenarios: with or without GPS.

A message can be forwarded to vehicles via base station. If Vehicle A knows there is an accident, it then passes the information to Vehicles B, C, D and E. We may determine a vehicle by Eq. 1 to store the message based on the principle of weighted p-persistence broadcasting. All vehicles in the coverage of AP will calculate their probabilities, and the vehicle with the highest probability is responsible for storing the message.

$$P_{ij} = \frac{D_{ij}}{R} \tag{1}$$

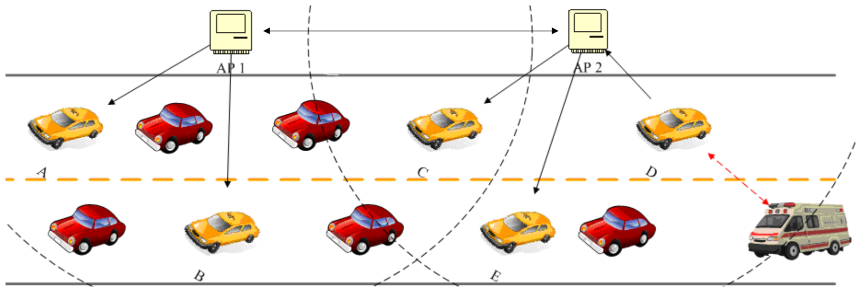

Fig. 2. Scenario I: Information classification

Message category is vital in determining the direction of broadcasting: if it is about an accident, the information is important for vehicles after it. If the message is about the coming of an ambulance, it is more important for the vehicles before the ambulance. We may attach a sign (+,-) to determine the direction of messaging. For example, Vehicle A in Fig. 2 sends out a message, and Vehicles B, C, D and E will receive the message with the sign "+". By contrast, Vehicle D in Fig. 4 senses an ambulance coming from behind and sends out a message, Vehicles A, B C, and E will receive the message with the sign "-". Directional information is very useful in practical use in that it helps to determine the probability of data storage.

In case no GPS signals are available, e.g., vehicles inside along tunnel, location-based messaging can be used instead [1]. As shown in Fig. 3, Vehicle A finds an accident and sends the information to the control center, whicc in turn will forward it to specified areas. The road should be divided into several sections beforehand.

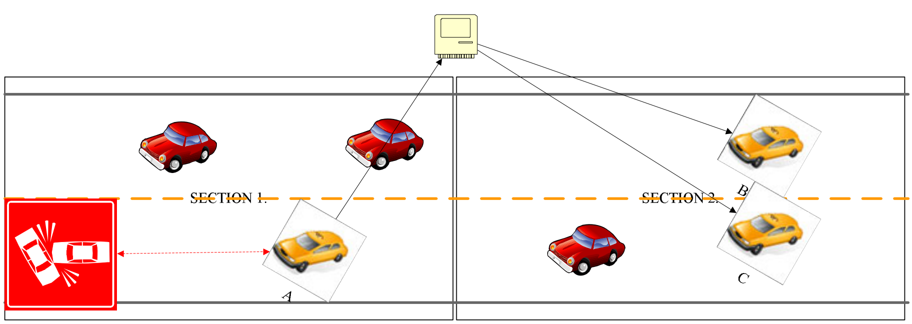

Fig. 3. Scenario II: Messaging in specified area

4 System Analysis

The system architecture for communication in Scenario I is illustrated in Fig. 4, where two peer vehicles determine the IP of their counterpart and communicate through Port 8080. They all make use of the Listener mechanism of the web browser to wait for messages sent by their counterpart.

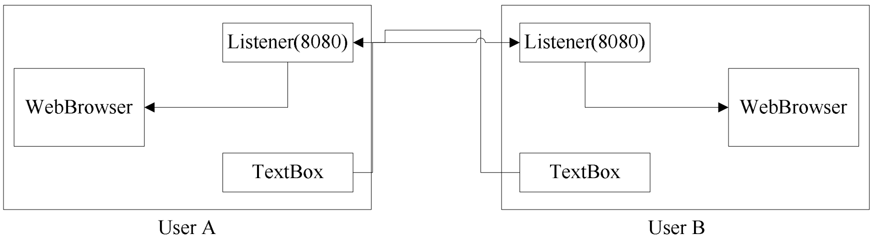

Fig. 4. P2P Communication architecture

Formula (2) is a string of GPS signals consisting of 15 parts in which 2501.9891, N, 12133.8101, E are used to extract location information. In the formula, L stands for longitude (or latitude), D for degree, M for minute, and S for second.

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$GPGGA,095031.254,2501.9891,N,12133.8101,E,1,07,7.0,
123.9,M,15.0,M,0.0,0000*74
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(2)

$$\mathrm{L} = \mathrm{D} + \left(\mathrm{M} * 60 + S/10000 * 60\right)/3600 \tag{3}$$

If all vehicles are equipped with GPS and there are access points (AP) on roadside, we use P2P communication either over LAN based on IEEE802.11x or mobile communication through 3G. If vehicles from the opposite direction would not help to carry a message, we then use disconnected mode for sparse traffic and regular traffic. Therefore, only well-connected mode and disconnected mode will be considered. In order to avoid a broadcasting storm, the system provides the user a function to decide whether to forward the message. In case no GPS signals are available, we use information push system as an auxiliary. An information push system is suggested to include three functions: message generation module, receiver allocation module, and message transmission module [1]. But their system is used for short message service; what we need for inter-vehicle communication is much more complex. A great extension of the system is expected.

Information involved in inter-vehicle communication includes event, vehicle direction, street, distance to an accident, traffic flow, IP of the sender, and remarks from the user. The Euclidian distance is determined as Eq. 4.

$$D = \sqrt{(X_1 - X_2)^2 + (Y_1 - Y_2)^2} \tag{4}$$

After receiving a message, a user then calculates his location and probability, and decides where to forward this message. If he is located in a disconnected situation (e.g., in sparse traffic), the server will locate an area and broadcast in his area.

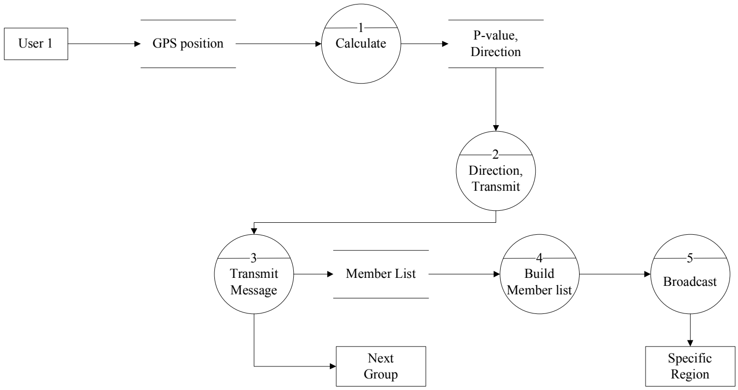

Fig. 5. Main modules of the inter-vehicle communication system

The system development environment was Visual Studio 2005 .NET Framework. We used VB to design the system functions and user interface. SQL Server 2005 was used to manage all necessary data. WiFi (802.11a) and 3G is the platform for communication, Blue Tooth or USB receiver was used to connect GPS, and all real-time data is displayed for supporting user's decision.

5 System Design and Implementation

User interface was intended for use in moving environment. The user sends out a message by touches the screen. Eight kinds of information are available. Output is in the form of text as shown in Fig. 6. The user interface is divided into 3 blocks: The upper block, which includes driver identification and car plate number; the middle block, which includes icons for 8 different kinds of information including car and road conditions; the lower block, which documents information.

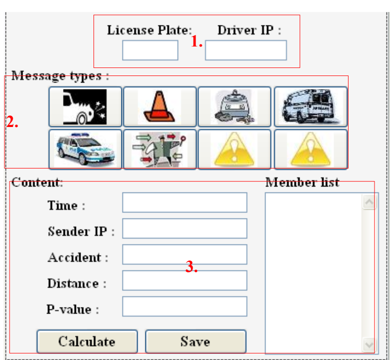

Fig. 6. User interface

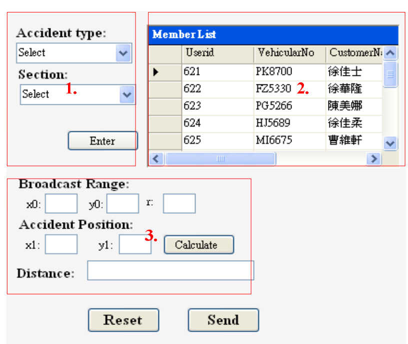

Fig. 7. Administrator's interface

In case no GPS signals are available, roadside access points are responsible for transmitting message. The message is initiated by driver and forwarded by the APs. At the control center, the administrator's interface is divided into 3 blocks: the left upper block is for administrator to enter information about an event; the right upper block is a list of members, and the lower block is a specification of broadcast.

The system is usually in IDLE state. When a message comes, it changes to GetMsg state to receive message. Then it tries to check GPS signals. If there are signals, then calculate its probability, the p-value. If the p-value does not exceed the upper limit, it then enters the state of KMsg and keeps the message. Otherwise, it changes into Re-broadcast state. Before sending the message, it checks the neighboring state. If the state is well connected, it broadcasts the message. If the state is disconnected, it forwards the message to the control center.

To activate the system, we first store the basic data of car plate number, IP, vehicle ID etc. In case there are no GPS signals available, the user should first determine the types of event and calculate the distance, and then set up a list of receivers and broadcast the message.

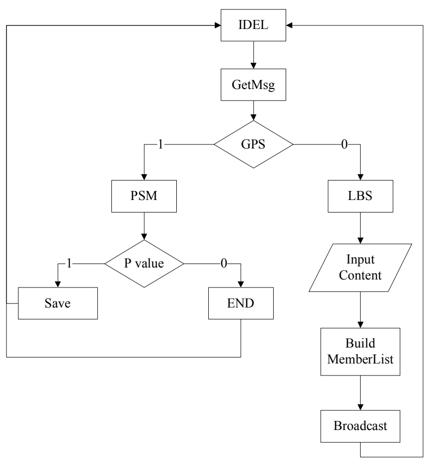

Fig. 8. Data flow of the system

6 Conclusion

Besides the conventional message broadcasting, the proposed system helps to manage a caravan taking into account message usefulness and avoidance of a broadcasting storm. In case no GPS signals are available, location-based broadcasting will be used to carry forward the message. The system is useful for managing taxis, police wagons, fire-fighters, ambulance, etc. In subsequent study, we will administer questionnaires to know its applicability when the system is put into practice. The Unified Theory of Acceptance and Use of Technology proposed by Venkatesh et al. (2003) will be the research structure of the empirical study. It is sugested to know the benefits of the system from the drivers in order to manage the caravan more efficiently.

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