A Practical Context Awareness Information System for VANET based on IEEE 1609

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Abstract. With the popularization of consumer electronic products and the promotion of digital mobile devices, telematics services are more important and practicable when the global positioning system (GPS) is commonly used in today's lives, especially adopting context awareness technologies. In this paper, we present a novel approach to support the environment of an open architecture for telematics services based on international standards, and the proposed approach (Context Awareness Application Server) can optimize context awareness mode features to provide personal tracking services to children and elders for safety reason. The simulations and experiments in this study have verified the effectiveness of the proposed approach.

Keywords: Context Awareness; IEEE1609; VANET; Telematics Platform; Particle Filter

1 Introduction

Vehicular ad hoc network (VANET) is a critical technology for automotive electronics applications. Most recently, VANET is an emerging technology which rapidly grows up and presents a very active field of research, development, standardization. Throughout the world, there are many national and international projects in government, industry, and academia devoted to VANET. These projects include consortia like Vehicle Safety Consortium (US), Car-2-Car Communication Consortium (Europe), Advanced Safety Vehicle Program (Japan), standardization efforts like IEEE 802.11p (WAVE), and field trials like the large-scale Vehicle Infrastructure Integration Program (VII) [1] in the US. VII field trials are mainly focused on telematics platform that are related to IEEE 1609 protocol.

In order to address the challenges of developing context awareness telematics platform, this paper presents our service-oriented approach to utilize data mining algorithm to convey and manage the transportation mode of the proposed system. The rest of the paper is organized as follows. Brief introductions related to context awareness over telematics system are depicted in Session 2. In Session 3, the proposed CAAS system model is described. We cover basic components of generic architecture of CAAS within telematics system including real-time monitoring and personal mobility analysis. Simulation results are shown in Session 4 to present the accuracy performance of the proposed scheme. Finally, this paper is concluded in Session 5.

2 Background

The emerging telematics is considered to be a key feature in mobile computing networks, such as vehicular network or cellular network. Car in the near future will likely be equipped with many embedded computing platforms capable of running general purpose applications. Our critical research topic is towards the development and introduction of application-specific telematics platform for mobile communications, while considering the scalability and interface issues. In a vehicular network, an OBU (On Board Unit) may attach from one RSE (Road Side Equipment) to another RSE or a base station of another wireless network while moving. When integrated into the transportation system infrastructure (through RSEs), and in vehicles themselves (through OBUs), these technologies help monitor and manage traffic flow, reduce congestion, provide alternate route to travelers, and save lives.

Tran et al. [2] presented a service-based approach to support the structural and behavioral adaptation of automotive telematics. In particular, the structure enables the separate development of telematics and the management of context and adaption. However, much work needs to be done to provide modeling/implementation methods and tools to support developers using such an approach. Choudhury et al. [3] developed a context aware framework to address the diverse communication needs of a modern enterprise. This method determines an optimal request-to-agent routing based on several metrics of effectiveness depending on the communication context. In other studies, Zhang et al. [4] [5] presented an approach based on supervised learning to automatically infer users' transportation modes, including driving, walking, taking a bus and riding a bike, from raw GPS logs. This approach consists of three parts: a change point-based segmentation method, an inference model and a graph-based post-processing algorithm.

We present our work in designing and building a telematics platform that can be used to deploy a variety of intelligent transportation applications. Current platform consists of three major components: CAAS, CAP (Context Awareness Platform), and OBU. CAAS is an application service that is based on CAP and provides capability of identifying current context of the user by analyzing dynamic data from clients. This is the essential to potential extensions to many mobile services. CAP is a platform which connects between multiple users, APs, OBUs, and GPS Trackers. It stores the information (e.g., latitude/longitude/speed) sent from OBU/GPS tracker into database and provides some functions to process the requests sent from APs. An OBU is embedded into each vehicle to connect to CAP to transmit up-to-date vehicle status, including vehicle location, OBD II (On Board Diagnostics II) information, and sensed information such as engine load, remaining fuel, and tire pressure.

3 Context Awareness Application System Architecture

3.1 CAAS System Model

In our project, we built a GPS-assisted wireless application to validate the design and implementation of telemaitcs platform that to provide service to end users. Fig. 1 shows the proposed system model with CAAS. As the function diagram below, CAAS service logic package classes include communication module, CAAS handler, notification handler, and utility. Communication module is used to process incoming XML data from the XML interpreter. Utility package includes database connection, XML parser, and sending request through CAP broker, and will be called when needed.

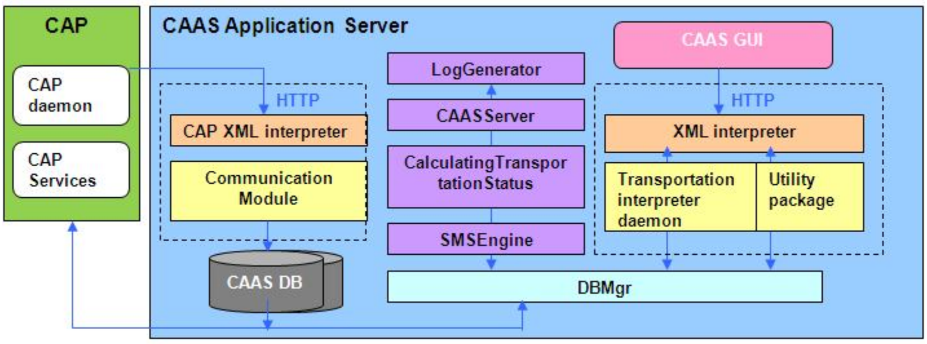

Fig. 1. The Core CAAS Main Functions

The key processes are described as follows: first CAAS core module obtains context raw data from CAP coordinates; then CAP are responsible for collecting all different kinds of raw data into one centralized interface to the upper layer. For the static data that previously saved in the CAAS database, it can be acquired form software sources or hardware system logs. Then context interpreter is the main functions which constantly receive real-time raw data from sources to translate them to high-level information. And context interpreter includes the data mining algorithms that are responsible for predicting the user's current situation like on-foot, motorcycle or bus from other contexts depending on GPS coordinates, speed, acceleration, and served units. There are one routine to trigger the transportation status to OBU when the method changed. Finally CAAS manager has a knowledge base which can provide flexible, scalable, and reliable query interface to context services which can retrieve context information using both query and subscription/notification mechanisms. The different kinds of context services can adapt them into GUI accordingly. Each component will be introduced briefly as follows:

- Real-time monitoring: Every GPS user that is under the surveillance of CAAS would be shown on the map in real-time. For the security reason, only the CAAS user can see the GPS users that s/he registers with.
- Personal mobility analysis: When the GPS user is shown on the map, CAAS also generates related information to display on the map, such as speed, idle time, etc. In addition, it provides information of this GPS user's mobility status, such as on bus, on foot, on bike.
- Geo-fence protection: GPS users have their own geo-fence that is previously defined by CAAS users. Once GPS users enter or exit certain geo-fence, CAAS will send alert to the designated contact that is also previously provided.
- Tracking and behavior report: CAAS provides map tracking and behavior report. Behavior reports show the distribution of time that each GPS user spends in the difference geo-fences and under different mobility status. This function can basically extend CAAS's usage not only for safety, but also personal health and business management.

3.2 The CAAS OBU Device

The CAAS OBU is a new design to achieve high performance and to support multiple applications on a vehicle. To achieve the feature that one OBU core can simultaneously support multiple OBU user interfaces, the OBU core is a middleware between the CAP and OBU clients. The OBU core has to connect CAP's authentication handler to perform authentication whenever it is started, and therefore it initiates connections to CAP's communication handler and context handler when it is already authenticated. The OBU core also provides socket interfaces for OBU clients to acquire necessary information, such as GPS location, meter state, and OBD-II states, and to communicate with the CAP through OBU core's communication handler. CAAS user interface communicates with OBU core through CAAS logic. CAAS logic is responsible for maintaining connections, sending probe information, and handling events. CAAS client also needs to request group members' locations from the CAP's web service after receiving the user ID from CAAS web administration to show group member's locations in Google Map. After user login, CAAS client will receive events from CAP's communication handler and display group members' latest status and transportation state. In addition, CAAS user interface will display user's up-to-date locations by clicking on the Google Map browsing button and sending the query request to CAP's web service. The screenshot in Fig. 2 (a) is the usual operational appearance with following elements: status, location, alert. In Fig. 2 (b), the screenshot on the right is user's location displayed on the map surrounding him. Supposing a user would like to learn his own position, his position related map data surrounding him will be displayed using a browser with his position & traffic status marked on map. Such display is triggered on prompt when the central magnifier-like icon is clicked. Note that the zoom level of the map is to be adjusted in accordance with user's status.

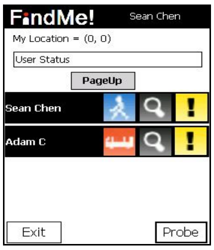

Fig. 2(a). CAAS OBU Interface

Fig. 2 (b). CAAS with Google Map

4 Experimental Evaluation

We took the experiments on the CAAS, the most important application in the proposed telematics system. The simulator simulated the behavior of entities in different traffic status by using the pre-collected data from different real traffic status. We collected a log of 10 days of GPS raw data from GPS phone. Assume transportation modes in the experiment are walking, biking, riding bus and stay; these modes influence the motion velocity. In this experiment, we first focused on the estimation of location and modes of transportation. For simplicity, the rule-based method was proved to adapt well in the environment of the CAAS, we also included a particle filter (PF) [6] model groups in comparison with CAAS rule-based method groups. PF is a variant of Bayes filters for estimating the state of a dynamic system. They represent posterior distributions over the state space with temporal sets, Xt, of n weighted samples: This definition is written as follows:

$$X_t = \left\{ \left\langle s_t^{(i)}, w_t^{(i)} \right\rangle \middle| i = 1, \dots, n \right\} \tag{1}$$

where each $s_t^{(i)}$ is a sample (or state), and the $w_t^{(i)}$ are non-negative numerical factors called importance weights, which sum up to one. We compared the performance of the rule-based method and the PF model under the same conditions. Fig. 4 shows the recall rate for the rule-based method and the PF model using different kinds of transportation modes. The PF model achieves higher accuracy since it updates the posterior distribution according to the sampling with re-sampling procedures. Once the transportation mode is sampled, the motion velocity is sampled from a mixture of Gaussians probability which is conditioned on the mode. There are two methods considered in two scenarios. Scenario 1 is shown in Fig. 3 (a) and the above-mentioned four transportation modes are employed to simulate scenario 1. Therefore, the average values of recall in the PF model and the rule-based method are 80.12% and 67.31%, separately. In the rule-based method, the average recall rate based on speed changes is about 12% lower than the PF model. Scenario 2 is basically the same as scenario1 except the transportation mode of walking and is revealed in Fig. 3 (b). The average values of recall in two methods are 67.62% and 62.71%. The PF model gets the better performance results. However, the variation between the two methods is not obvious; the average value of recall in the rule-based method is almost the same as that in the PF model. According to the simulation results, the PF mode is just a little better than the rule-based method with the improvement of about 5%.

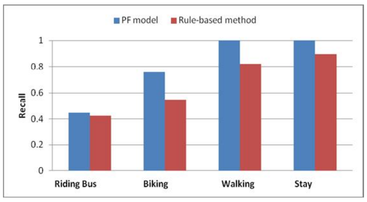

Fig. 3 (a). Recall of the rule-based method and the PF model based on speed changes

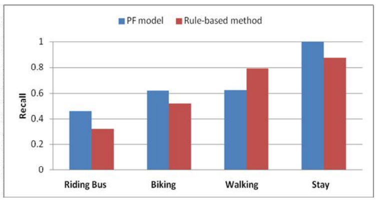

Fig. 3. (b). Recall of the two methods based on the accelerating speed changes

5 Conclusion

In this project, we aim at investigating in-car wireless network, inter-vehicle network and OBU devices communication protocol. We have worked on a comprehensive state-of-the-art analysis of the emerging VANET technologies and protocols that hold the potential of supporting a multitude of advanced and innovative applications in the next generation of intelligent vehicles. This work also presents a new distributed traffic information system for computing transportation mode based on the limitation of GPS raw data. In the future, we will strive for improving the predication performance of CAAS by designing a more sophisticated algorithm.

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