A New Framework for the development of AVL based Transport Monitoring System

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Abstract—Automated Vehicle Location (AVL) based Transport Monitoring System has created some interest to many researchers. Currently, the implementation of AVL based Transport Monitoring System rely on the Global Positioning System (GPS) data, which can produce real time location of a vehicle. Implementation of a complete Transport Monitoring System requires other components such as communication module, Geographical Information System (GIS), database and monitoring application to be included into the system architecture. Once all the elements are put together, the project might become quite complex and very difficult to be deployed in a relatively short development cycle. In this paper, we propose a new approach on the design and implementation of a Transport Monitoring System that will not only make the project more manageable but will also enhance it by offering extended collaborative features. This new language-based platform will also allow modular experimentation of various optimization algorithms to be designed, tested and selected for better system performance. With the proposed framework, AVL based Transport Monitoring System can be implemented economically and efficiently. Comparison analysis among available AVL based system framework is also performed to show that this research work is feasible.

Key-Words: - Automated Vehicle Location (AVL), Collaborative environment, Multimedia communication, Transport monitoring, Route optimization, Scripting language.

1 Introduction
The basic ideas behind this research originally concerned about the problems in the logistic distribution process which needs accurate decision on how to economically and reasonably consign goods to customers with high efficiency at the lowest cost possible. Vehicle Routing Problem (VRP) that directly influences customer service level and distribution cost is one of the major problem. It may involve in finding the optimal routes for vehicle delivery under certain constraints such as vehicle location, capacity, time and customer demand. In order to reduce VRP domain, proper planning shall be done to the entire distribution process that mainly involves management of vehicles travelling along targeted routes.

Towards resolving this problem, Automated Vehicle Location (AVL) based Transport Monitoring System has created some interest to many researchers. A variation of system architecture and functions have been proposed for AVL based Transport Monitoring Systems. Generally, these systems were intergrated with database, optimization module, monitoring and communication components as well as utilizing Global Positioning System (GPS), Geographical Information System (GIS), General Packet Radio Service (GPRS) and Short Messaging Service (SMS) technologies. The integrations of components and technologies might probably involved various level of data communication and component interactions especially when the system in the collaborative environments.

To date, the implementation of AVL based Transport Monitoring System in many developing countries as well as in Malaysia is still in its infancy. This is most probably because of the high development cost in terms of expertise for implementing such kind of system that requires high level network programming skills. In the development process, the most important and
difficult issue is to create mechanisms for controlling interaction among components, data, protocols and users simultaneously. By considering at least four important activities like zone monitoring, vehicle searching, map navigation and spatial data manipulation, there should be an incorporation of various interaction protocols. Each one will require different critical collaborative interaction management. In the case of shared data, it should have some proper management of interest on issues like data sharing, filtering and security.

The framework for developing an AVL based Transport Monitoring System proposed in this paper has been designed to overcome the difficulties mentioned above. In this proposed framework, the system can be implemented using special purpose scripting language, called JACIE (Java-based Authoring language for Collaborative Interactive Environments) [1, 2].

This paper is outlined as follows. Section II presents the related work including current AVL based system architecture, development tools and vehicle route optimization algorithms. Section III explains the overall system framework and describes the software tool used for the implementation. Section IV gives a comparison analysis that has been performed on current frameworks and the proposed framework before the concluding remarks in Section V.

2 Related works
2.1 Automated Vehicle Location (AVL)

The location of a vehicle can be traced through a number of different technologies. Currently, the most common technology used for AVL is the Global Positioning System (GPS), a constellation of 24 satellites around the Earth that are constantly transmitting their position [3]. Generally, the architecture of the AVL based system proposed in [4-9] were included with some common components namely as command centre or management terminal, network and communication module, monitoring terminal, vehicle terminals and data server. The vehicle terminal has been considered as mobile terminal since it was installed in vehicle while the rest of the components have been located or setting up in the dispatch or command center. Prior to AVL based system, SMS technology was used as a communication channel between vehicle terminals and dispatch center. However, SMS communication is very text limited (only 140 bytes per SMS) and having uncertain delay (caused by short messaging service center) [5]. In order to overcome the SMS shortcomings, General Packet Radio Services (GPRS) was introduced to replace the SMS for better AVL based system [5, 7, 9]. GPRS is a network computing solution which is compliant to Internet Protocol (IP). It has become de facto that Internet solution is the cheapest communication infrastructure and most reliable compared to other network solutions for example SMS or Public Switch Telephone Network (PSTN).

Most of the communication in the current systems are among systems or inter-system [5, 7, 9, 10], and none has been mentioned about the communication channel used among users in the system. Although the WEBGIS-based system model [9] provides interfaces via web browser for users to perform vehicle monitoring, it has not been defined in details about the communication medium among users. Hence, it can be concluded that all the systems mentioned above have limited means of collaboration between users. By utilizing the benefits of IP based network, users working in the collaborative environment, should be given flexibilities in multimedia communication. Moreover, multimedia communication especially through the web is well known as an independent platform, cost effective (using IP network) and high scalability medium of communication.

2.2 Development tools and languages

Development of AVL based system can be done using various different development tools and languages. As for example, in the development of Vehicle Monitoring System (VMS) in [7], the researchers used application of MapX 5.0 for the mapping process and manipulation. Map X can be quickly integrated into client side applications using Visual Basic, PowerBuilder, Delphi, Visual C++ and other object-oriented languages.

Pathfinder Tools software development kit [11] is another tool that can be used for the realization of AVL based system. Pathfinder tools were included with four OCX (Active X) controls for configuring, controlling and monitoring of GPS receivers. It was enabled with functions for easy conversion of GPS coordinates and units. Developer could develop any AVL applications with their preferences languages such as Visual Basic and Java, and then incorporate the Pathfinder Active X controller into the application.

The two examples of AVL tools given above, required programmers to use any general purpose programming languages for the development of a complete Transport Monitoring System. Furthermore, in developing collaborative
multimedia environment for Transport Monitoring System, the programmer must have expertise in using powerful general purposes languages like C or Java and high level capabilities in using network programming elements like sockets, streams, thread and remote management interface (RMI).

In recent years, a variation of development tools also have been introduced to support the development of collaborative type applications. However, many of them targeted to be used for a small class of collaborative applications[1] and they provide software library for network programming in a very limited way [2]. Since the interaction management and data sharing are very important aspects in AVL based Transport Monitoring System, these current development tools by no means provide the developers with interaction and communication protocols.

2.3 Route optimization algorithm
Route optimization algorithm is a method that constitute towards minimizing the travelling cost in vehicle routing problem. Based on some studies on current AVL based systems, there are some of them that integrate route optimization functions. For example, in [4], the Ant Colony Algorithm has been adopted to improve vehicle route optimization, but the overall system framework was not explained in detail. Rather than focusing on tool for route planning and optimization handler, the paper focuses more on the map manipulations in GIS application. Dalia et al. [12] proposed a Nearest-Neighbor Trajectory (NNT) algorithm to predict the future movement of a vehicle. The prediction could be done by identifying the historical path of vehicle locations that would generate trajectory pattern with the most similar to the current pattern. This method had been defined by the authors as similarity based prediction. Another method, called metaheuristic was also applied into vehicle routing. The most popular types include ant colony, genetic algorithm, greedy randomized adaptive search procedure, simulated annealing, tabu search and variable neighborhood search [13].

3 Framework
The overall system framework that will be developed from the proposed development tool is shown in Figure 1. Based on a Client/Server (CS) model, intra-systems and user communication is supported by IP based network solutions.

The GPS receivers will be installed in vehicle terminals that have wireless communication in GPRS network. All the GPS data like longitude, latitude, time and speed of vehicle will be transferred to the central database server in a form of User Datagram Protocol (UDP) data packet and upon arrival at the destination server, the data packet will be extracted and stored into the database server. The reason to use UDP data packet is to reduce delay when congestions of network line occurs during transmission from GPRS network to central network. In order to provide more reliable and secure connections between local central network and remote monitoring sub-centre, the Transfer Control Protocol (TCP) will be used as the transport protocol. TCP which is known as connection-oriented protocol has the capability on controlling connection errors at service or port level of terminals [14]. Thus, only the right or upon agreement operations will be executed. Since TCP provides more reliable data flow, the packet size is longer than UDP. Figure 2(a) and Figure 2(b) illustrate the packet size of UDP and TCP respectively.
In the database server, the table relationships have been designed precisely among the GPS data, vehicle and driver information so that information can be viewed and tracked effectively. A system administrator will be given authority to manage database data for example to add or delete vehicle and driver information. The management of collaborators’ account, group and functional authorities can be done through the management terminal located at the operation center. The process of managing map manipulations and displaying vehicle location will be handled by GIS application server. Communication among collaborators from monitoring center and sub-centers can be attained through a discussion terminal with a variety of build-in multimedia communication channels such as text, voice or video messaging. The route optimization server is responsible to manage all optimization requests from the monitoring center. One major part of the route optimization server is route optimization functions handler which provides flexibility for users to run or test various route optimization algorithms. The collaborative server provide functions in handling interaction protocols among collaborators and sub-systems.

The new proposed components (Route Optimization Server, Monitoring Center and Collaborative Server) will be implemented using a high level language, JACIE [1,2] for flexible route optimization and collaborative environment.

3.1 Language-based platform - JACIE

From the scripting language editor, programmer can implement and call the predefined functions that has been constructed in the JACIE platform. JACIE is a software development tool that enables distributed collaborative applications to be developed at a very low development cost, within a short development period, and by possibly inexperienced programmers [1, 2]. The type of applications that are possible to be developed with JACIE may include virtual meeting, collaborative editing, e-learning, web-based games, collaborative monitoring and many more.

In this research work, we choose JACIE as the development platform due to several reasons. Firstly, JACIE contains a collection of built-in language constructs for supporting structured and unstructured communications. There are five built-in communication channels that can be used in JACIE namely as canvas, message, chat, voice, video and whiteboard. These communication channels will provide extra flexibilities and ensure effective communication among collaborators in the AVL based Transport Monitoring System. Secondly, it is originally designed as a scripting language and its compiler will automatically generate Java codes for the developer. The scripting language can be easily understood and used by any programmer. JACIE also allows the inclusion of Java code as part of a JACIE program, enabling experienced programmers to utilize Java for the implementation of complex code segments [1]. The last reason but very important is because JACIE provides flexibility for developers to use the varieties of robust build-in collaborative interaction protocols[15, 16]. The JACIE architecture can be seen in Figure 3 [2].

A set of language constructs will be added into JACIE to permit programmer in using the predefined built-in route optimization modules. Programmers will also be able to define their own route optimization algorithms in order to develop algorithms that specifically fulfill the requirements or problems needed.
4 Analysis
The technology used in some AVL based Transport Monitoring System frameworks in most systems [4-9] have been compared with the new proposed framework in this research. Referring to Table 1, it clearly shows that the proposed framework is the only framework that provides multimedia collaborative environment to the system. Furthermore, there are flexibilities in choosing or developing route optimization algorithms in making this new framework more efficient than others. While the collaborative feature allows monitoring center to work together with the sub-centers, route optimization handler allows various algorithms to be tested for better routing selection.

Table 1: Comparison analysis among current frameworks with the proposed framework

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<tr>
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<td>X</td>
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<td>X</td>
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<tr>
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5 Conclusion
The creation of the new framework is expected to benefits a lot to the current system architecture. With the integration of multimedia collaborative environment, a lot of research works can be carried out in the future. The accuracy of data conversion and reliability of the information generated will be different in collaborative environment especially when it involves factors of time and speed like the GPS sensor data. These factors may also contribute to the performance of algorithms used for vehicle route optimization. Since collaborative applications require network communication and protocols, it is necessary to study on the data and network performances during the implementation of AVL based system in collaborative environment.

The capability of handling various route optimization algorithms proposed in this framework will also require evaluation for the route optimization performances. Lastly, the scripting language proposed in the design and implementation of this framework will probably reduce difficulties in developing AVL based Transport Monitoring System. However, feasibility studies on such scripting language should be performed to assure that the AVL based system can be developed efficiently.

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