

Exploration of Automatic Vehicle Location in the Project54 system

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Introduction

The prevalence of today's Global Positioning System (GPS) devices has enabled many transit and fleet authorities to provide Automatic Vehicle Location (AVL) for better organization. AVL systems have the ability to track the position of individual vehicles and to relay that data back to a remote location, such as a dispatcher, that can store or better utilize the information. The implementation of an AVL system within a police department, to automatically log and keep track of the location of each cruiser, is of great benefit to both the department, and the public. Not only could this provide critical information when locating an officer in danger, it could eventually be utilized to aid dispatchers in vehicle deployment.

In an effort to determine the practicality of using such technology as it exists today, Project54 (P54) has begun to install AVL capabilities in a limited number of New Hampshire State Police cruisers, taking advantage of the digital radios and GPS receivers already installed in each cruiser to transmit the AVL data. Because the New Hampshire State Police use a 9600 bps connection, an important area of investigation is the determination of the frequency at which the AVL data is relayed back to headquarters (HQ). The limited bandwidth of the radio must be shared amongst the AVL and other systems in multiple cruisers. Additionally, the reliability, accuracy, and precision of the

GPS data and the AVL system must be explored through the testing of numerous cruisers under real world conditions.

GPS overview

While GPS is not the only technology available to generate AVL, it is frequently employed. Built and maintained by the United States Department of Defense, GPS consists of a constellation of 24 satellites from which a GPS receiver can determine its three-dimensional location, via triangulation [1]. The three dimensions are expressed in longitude, latitude and altitude. The orbits of the satellites were designed so that at every point on Earth at least four satellites can be utilized, at any time. Each satellite is continuously transmitting position and time information. It is from this that the GPS receiver determines the distance between itself and each satellite, and then uses triangulation to discern its own position on Earth.

Atmospheric delays, satellite/receiver clocks, and slightly altered orbits contribute to error within GPS calculations. To help compensate for the error that occurs, Differential GPS (DGPS) can often be employed [2]. In DGPS a GPS receiver at a known location receives the data from “visible” GPS satellites. Because this receiver knows its location, it can determine the error associated with each satellite. This error information is then transmitted to nearby roaming GPS receivers, so that they can take into account the error when calculating their position. DGPS is not always available to a roaming GPS receiver, thus further investigation is needed to determine how often this lapse in service occurs.

The GPS receivers used during this testing period output two different types of GPS sentences. The first type is GPRMC: the Recommended Minimum Specific GPS/Transit Data. This sentence type contains time, longitude, latitude, speed, date, magnetic variation and a navigation receiver warning. The second sentence type is GPGGA: Global Positioning System Fix Data. Time, latitude, longitude, fix quality, number of satellites, horizontal dilution of precision, altitude and height of geoid (mean sea level) above WGS84 ellipsoid are included in this sentence. The GPGGA sentence includes information that can be used to determine the quality of the data received by the GPS receiver. Horizontal Dilution of Precision (HDOP) is a measure of how accurate the longitude and latitude measurements are, as a result of the geometry of the satellites used to obtain them. It takes the form of a number 1 through 50, 1 being an ideal measurement. Fix quality refers to whether or not Differential GPS (DGPS) was used in the measurement.

Overview of AVL code

The current AVL code contained in the P54 software follows a minimum time (`min_time`), maximum time (`max_time`) and maximum distance (`max_distance`), guideline. When the AVL code within the P54 software receives data from the GPS receiver, it determines how much time has passed since it relayed AVL data to headquarters. By comparing this value to the values of `min_time` and `max_time`, as shown in Figure 1, the code determines whether the data should be discarded or transmitted. For ease of use, the `min_time` and `max_time` and maximum distance

parameters are set by registry key. This is meant to facilitate any adjustments made to the time and distance parameters.

Once it is determined that the received AVL data will be transmitted to HQ, the AVL code appends a counter to the report. The counter allows a person at HQ to determine if any reports were lost during transmission. Currently HQ sends no acknowledgement to the cruiser, so the AVL code will not try to retransmit any reports that were lost.

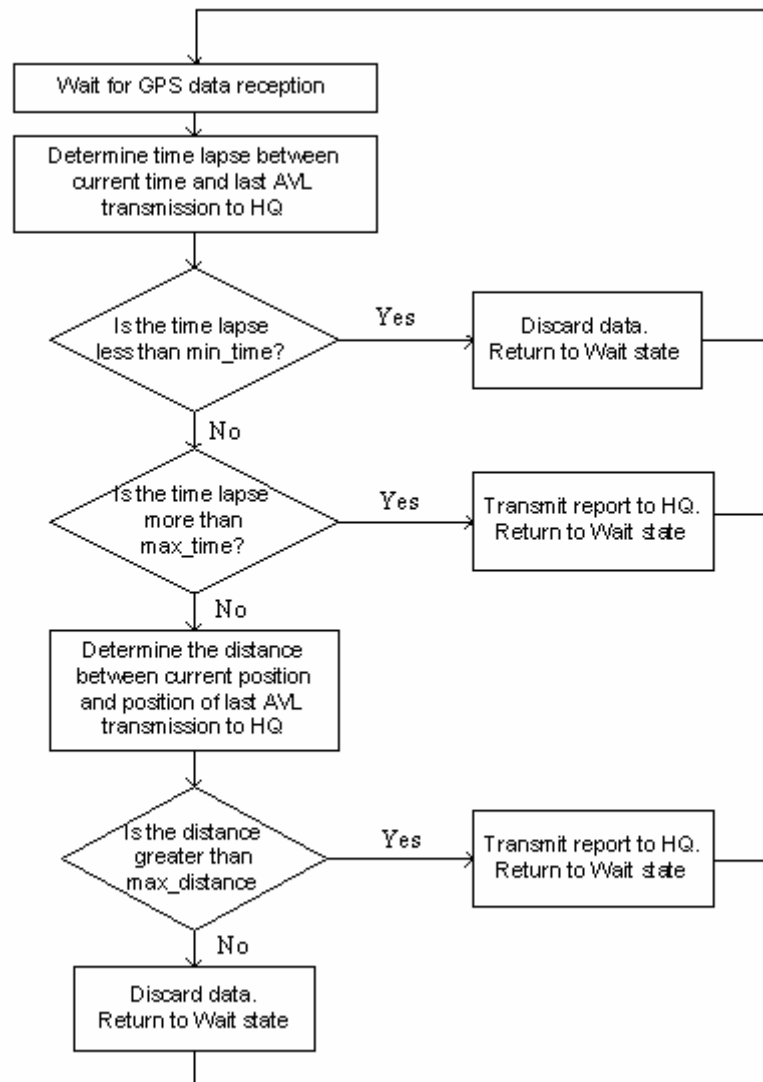


Figure 1. State diagram of AVL decision code

Upon receipt of an AVL report, software at HQ adds the report to a text file, which is named after the IP address of the cruiser. This simple naming convention allows a basic method for keeping AVL data organized by vehicle. Each day a new folder is created named for the current date. It is in this up-to-date folder that the text files are created, with names that correspond to the cruisers' IP address, so that AVL information may be stored in an organized manner. For example, inside a folder named Nov_19_04, there may be two text files, one called IP10_1_54_2.txt and the other IP10_1_54_1.txt, containing the AVL reports generated by two cars on November 19, 2004.

Initial testing methods

Accumulating standards for information quality plays an important role during the testing process. The initial testing of the AVL system in the cruisers has two main objectives. The first is to determine appropriate values or ranges for the parameters min_time, max_time and max_distance. The second objective is to determine the accuracy of the locations provided by the AVL reports, as accuracy is paramount when determining the value of such reports.

Due to the limitations of the communications system used by the New Hampshire State Police voice traffic cannot be transmitted at the same time as data traffic, and data can only be sent by one cruiser at a time. This implies that making AVL reports too frequent will overload the system. However, sparse AVL provide little usefulness. For initial test purposes, the min_time was set to 7 minutes, the max_time set to 10 minutes and the max_distance set to 4 nautical miles. These values were chosen to be conservative so that test code could be added to multiple cruisers while keeping the rate

of AVL reports sent to HQ limited. A second reason for limiting how often AVL reports are sent is that the P54 code used to transmit data to HQ via digital radio, the P25Proxy, is also in a testing phase [3]. While rigorous and continuous testing of the P25Proxy code is desired and could be accomplished by transmitting frequent AVL reports, any issues that may occur may interfere with the operation of the digital radio or P54 system and thus cause distraction to the officer in the cruiser.

The quality of the GPS data contained in the AVL reports will be analyzed several ways. The initial stage of the analysis is data collection. During this stage test AVL code will be installed in multiple cruisers, and all of the AVL reports, containing GPRMC and GPGLL sentences, are logged in files in a server at HQ, generating a bank of data. From this compilation of data, statistics will be calculated. Such statistics include percentage of reports with: an HDOP greater than 5, a fix quality that does not include DGPS, and less than 5 satellites utilized. One benefit of having a bank of readily available data is that new statistics can be generated without having to run through the data compilation process again.

A second type of quality test tracks the precision of the GPS data. For this, a cruiser with AVL code installed and running will stay motionless throughout a long period of time, a day for instance. From the AVL reports that are gathered during this time frame, the variations between the calculated positions can be observed. Ideally each report would contain exactly the same longitude and latitude - the smaller the variation between individual calculated positions, the better.

Future development

Once the AVL system has been fully tested and optimized, widespread deployment will begin. Many improvements to the basic system being tested may be made. Due to the short length of the AVL reports transmitted to HQ, additional pieces of information may be appended by the software to better utilize the available bandwidth. Such information may include data obtain from on-board diagnostics (OBD-II), status of the lights and siren or important information originating from the Project54 software.

In addition to creating a text file record of location information, AVL may be used in conjunction with a digital map to provide a graphic display of cruiser position. This concept has been explored by other organizations and companies, such as in city buses [4]. This would provide a method for dispatchers to easily obtain location information of multiple cruisers, and therefore make faster decisions about which cruisers to deploy in emergency situations.

References

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