GNSS for Dynamic Road Pricing

Dinesh Manandhar, Ryosuke Shibasaki
Center for Spatial Information Science, The University of Tokyo
dinesh@csis.u-tokyo.ac.jp

Biography

Dinesh Manandhar is a Project Associate Professor at The University of Tokyo. He is currently involved in developing GNSS signal authentication system and promoting GNSS technologies and its applications abroad.

1. Introduction

Many countries have road pricing system for highways or expressways. It's also called toll charge. These toll charges are collected manually or using an automated electronic gate. Some countries also have road pricing based on traffic peak period such as Singapore's ERP (Electronic Road Pricing) system. However, all these systems require huge and costly infrastructure on the road side. It also requires high operation and maintenance costs. ERP system in Singapore is developed to manage traffic congestion during the peak hours. However, it is not possible to install ERP gates to cover all major road sections due to limited space and huge infrastructure cost.

In order to solve such problems, we propose to use only GNSS-based road pricing system. However, there is also a big risk of spoofing the GNSS receiver device to falsify location data to avoid payment. Thus, it is necessary to have a GNSS receiver system that is spoof-proof. If a spoof-proof GNSS receiver is available, road charging system can be developed based on GNSS only. In this presentation, we will briefly discuss about the use of a spoof-proof receiver for dynamic road pricing and test results of prototype system conducted in Singapore.

2. Spoof-Proof Receiver

We have developed a prototype spoof-proof receiver that broadcasts digital signature data in navigation signal of QZSS signal. This system is also capable of authentication of other GNSS signals such as GPS, Galileo or BeiDou by generating digital signature from its navigation message. This digital signature will be verified in the receiver by using a public key send to the receiver through internet. The digital signature is also broadcast from internet to the receiver since it is not possible to broadcast from the satellite at the moment.

3. Dynamic Road Pricing (DRP)

Our definition of dynamic road pricing is to charge road users based on traffic congestion, day, time and route chosen. There may be other factors as vehicle types etc. but in this prototype system, we are limiting to only the above few factors. Thus, the price may vary depending upon time for using the same road on different days and times. The purpose of DRP is to better management of traffic congestion and to assist MaaS (mobility as a Service). It is also possible to reward a road user instead of charging for selecting certain road sections to avoid traffic congestions.

4. System Architecture

The DRP system consists of a spoof-proof GNSS receiver. Android APK SecureNav computes road charges based on route, date and time. Charges are displayed on the device screen.
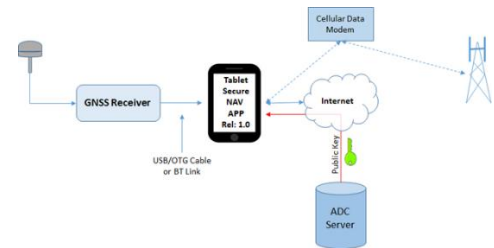
5. Test Results

The figure below shows screen captures of DRP program. The middle image shows sky-plot of visible GNSS satellites. Satellites with Green bars are authenticated signal satellites to indicate that the signals are not spoofed. If a signal is spoofed, it is shown by red color. The test results were quite satisfactory to use GNSS as road pricing

system. We will further develop the system with more advanced features and security features. This system can also be used to conduct field verification tests in Japan.