UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

SENSITIVITY ANALYSIS OF CODE CARRIER COHERENCE IN THE GPS SATELLITE FLEET TO REDUCE OVERBOUNDING IN WAAS TO INCREASE AVAILABILITY WHILE MAINTAINING INTEGRITY

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

Degree of

DOCTOR OF PHILOSOPHY

By

CHAD S. SHERRELL
Norman, Oklahoma
2016

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between usability and safety. For the FAA these are in the terms availability/continuity for usability and integrity for safety. If the system remains off then this is the highest level of integrity, meaning if the user does not use the Global Positioning System (GPS) then they are safe against all GPS related threats. This would not make a practical system, so it led the engineers developing the WAAS application to use values that would allow the system to be usable, but were significantly conservative to protect the user against GPS related threats. At the inception of WAAS there was insufficient empirical data to appropriately set many of the integrity bounding limits. At least one value was stated as being grossly overbounded and that the empirical evidence to set it correctly would require many years of data. The NASE organization has now accumulated the several years of data, but there is currently no analytical system in place to process this volume of data so that updated OSP values can be set.

Currently in this research effort the beginnings of a system has been created that can be used as an analytics platform for getting the varying data formats and elements into a common format where meaningful analysis can be performed. Every components in the system is purposely selected or designed to take data from its rawest form and process it into a format that can be utilized, manipulated and assessed. As of this writing the system can process NovAtel GUST, G-II and G-III GPS receiver binary log files. The software can identify receiver log messages, Cyclic Redundancy Check (CRC) check that the messages is valid and break each message type into its constituent elements for storing and further analysis. This has been fully demonstrated end to end on a Geostationary Earth Orbit (GEO) Satellite monitoring system in development. This system is currently monitoring one GEO satellite at one GEO Uplink Subsystem (GUS) site but will be expanded to four GEOs at 8 GUS sites in the near future. It process data from the WAAS application receiver and a second receiver used for fault isolation. The system is

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Chapter 2

Background and Literary Review

2.1 GPS Overview

Chapter 1 introduced LAAS, which is based on the Global Positioning System developed by the U.S. Department of Defense (DOD). GPS is a remarkable system for finding one's location and its success is largely due to the modest needs of the average user. Standard GPS accuracy is approximately 15 meters[3] and this level of accuracy is quite satisfactory for many applications, including land navigation, which is the primary consumer application for GPS. However, when GPS accuracy is discussed it is generally in terms of horizontal accuracy. Vertical accuracy is seldom mentioned in the discussion of accuracy and most GPS manufacturers do not publish the vertical accuracy specification. Due to this, a rule-of-thumb has developed that suggests that the vertical accuracy is only half as good as the horizontal accuracy. So, if Standard GPS is accurate to within 15 meters in the horizontal, then it is considered accurate to about 30 meters in the vertical, which is unacceptable for aircraft landings. This is why LAAS is indispensable for a GPS Landing System (GLS). Many different factors affect the precision of GPS which will be explored during this overview of the Global Positioning System.

GPS is comprised of 24 well placed satellites. The satellites orbit the earth in 6 orbital planes that are at a 55^o inclination with 4 satellites per plane such that at least 4 satellites will be above the horizon at any given moment. This allows users the ability to use the system 24 hours a day anywhere on the planet. These satellites are not geo-orbital, but are at a Medium Earth Orbit (MEO) and orbit the earth twice a sidereal day with a speed of 3.9km per second. The basic principal of the

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in workload, as well as provide high availability, additional virtual machines can be provisioned and when the demand subsides the virtual machines can be deallocated. The use of virtual machines can streamline development since they can repeatedly be created and destroyed to test out configurations.

Vagrant with VirtualBox Provider

The first component of the solution stack is vagrant. Its primary use is to create and configure virtual development environments. It also helps manage those virtual environments with a few very simple commands. The advantage of using this product is that is can be used by anyone on any platform that Vagrant supports to bring up an identical working environment. Through a Vagrant configuration file it can even constrain the virtual image to a specific version or versions of a image. It also has the capability to automatically install all the additional required applications in the solution stack so that when the system boots up the first time all required software has been installed and configurations have been completed.

This solution stack currently uses Oracle VirtualBox, but it is compatible with other virtualization software like VMware and KVM. The final virtual machines will run on VMWare in a blade cluster.

Vagrant Lifecycle Management

Command: vagrant init [box-name] [box-url]

By default Vagrant will use the containing directory of the Vagrant initialization file, called Vagrantfile, for the virtual machine name. To get started with Vagrant, first create a new directory and change into that directory.

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mkdir WAASAnalyticsPlatform && cd WAASAnalyticsPlatform
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The following commands initialize the current directory to be a Vagrant environment by creating the initial Vagrantfile. The Vagrant virtual image is known

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Chapter 4

Results and Discussion

Currently the graphite database contains 1213 data element. In the plot below each data element is the leaf in the directory tree represented by a file icon. This plot for one the psuedorange and standard deviation from the GPS receiver. Each data element contains a data point for each second of the day, 86400 points. This is just a first cut at getting data loaded into the system, but the design will support many data elements and calculations done between elements.

Chapter 4

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Appendices

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