Data Processing Design of Korean WA-DGNSS Reference Station

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ABSTRACT

WA-DGNSS provides the correction data and integrity information to the user via geostationary satellite. WA-DGNSS comprises Wide Area Reference Station, Master Station and User. Wide area reference station (WRS) receives data from the GNSS satellite, performs quality monitoring of decoded navigation data, and sends the correction data to wide area master station (WMS) via terrestrial communication network. WMS processes the data collected from the WRS, and uplinks the calculated correction data and integrity information to the geostationary satellite (GEO). GEO satellite downlinks the correction data to the users such as aerospace, marines, land applications etc for accurate and reliable positioning. Preliminary design results of WRS software are described in this paper, and it provides flexibilities in terms of modeling as well as system by taking modular software design approach.

1. Introduction

In Korea, technologies on WA-DGNSS (Wide area differential GNSS) are being jointly developed by a consortium of universities and research organization [1, 2, 3, 4, 5] for the construction of system in the near future. WA-DGNSS system comprises WRS, WMS/GES, GEO satellite and User segment (Fig. 1). WRS performs the quality monitoring of navigation message decoded from the received GNSS (GPS, Galileo etc) satellite, and transmits the monitored date to the WMS via terrestrial communication network. WMS generates the correction messages by processing the date received from

WRSs, and uplinks them to the GEO satellite via GES (Ground Earth Station). GEO satellite transmits the correction message and its own navigation message to the user with the same frequency as the GNSS satellite.

WA-DGNSS compensates for the disadvantages of GNSS in terms of accuracy, integrity, continuity and availability. Standalone GNSS cannot satisfy the ICAO requirements. Consequently, standardization on SBAS, namely GNSS augmentation system, is being carried out by ICAO. SBAS broadcasts GPS correction message and its integrity in real time via GEO satellite in wide area. WAAS, EGNOS and MSAS provide services in the U.S., EU and Japan respectively. Also GAGAN, SDCM etc are being planned operational in India, Russia etc.
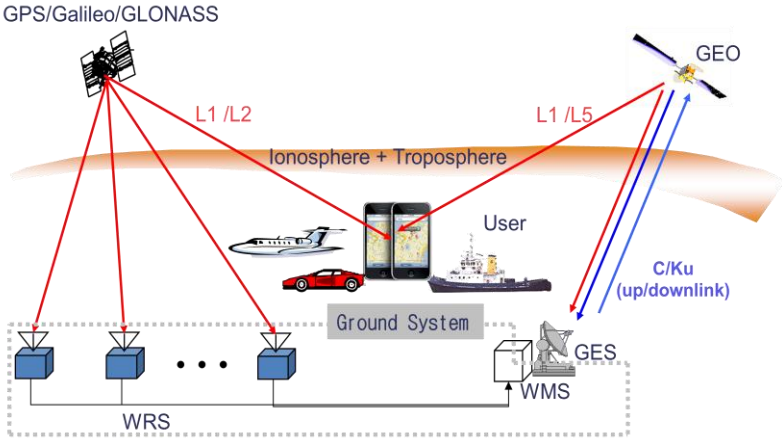

Fig 1. Korean WA-DGNSS Architecture

WA-DGNSS monitors all the visible satellites, also monitors the ionospheric delays etc in real time over the service area. It helps user enhance the navigation solution as well as compute the integrity bound by broadcasting the correction data and its integrity information to the user. WA-DGNSS broadcasts the correction data via GEO satellite with same frequency as the GNSS, wide area users can utilize the correction data without additional antenna.

This paper describes the efficient software design results of WA-DGNSS reference

station that will be constructed in Korea in the near future. The design results include data type definition from WRS to WMS and corresponding detailed interface flow. Data to be transmitted from WRS to WMS include preprocessed data required for generation of correction information, ION/UTC parameter for WRS and GNSS ephemeris data. Preprocessed data include WRS basic data and information on delays for troposphere and ionosphere etc.
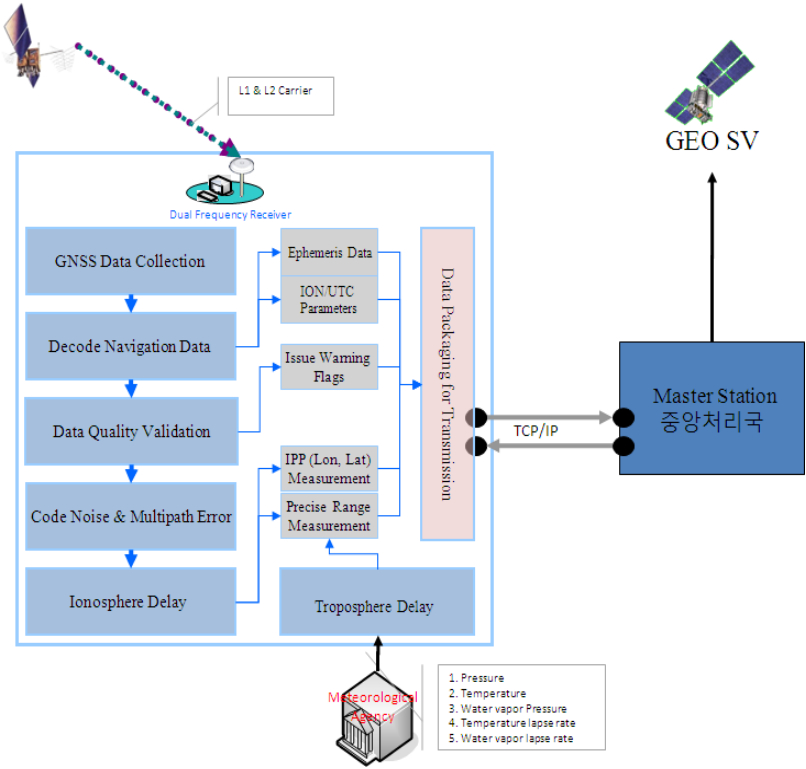

Fig 2. WRS Architecture

2. Data Processing in WRS

Quality monitoring of GPS data is carried out at the WRS. WRS analyzes the data status of the received GPS signal, and sends them to the WMS after estimating the errors related to ionospheric delays etc. WRS consists of GPS Receiver, correction data generation module, meteorological station and interface with WMS (Fig. 2). WRS

continuously checks the validity of GNSS navigation data, and the GNSS navigation data includes ephemeris, system time, satellite clock correction data etc.
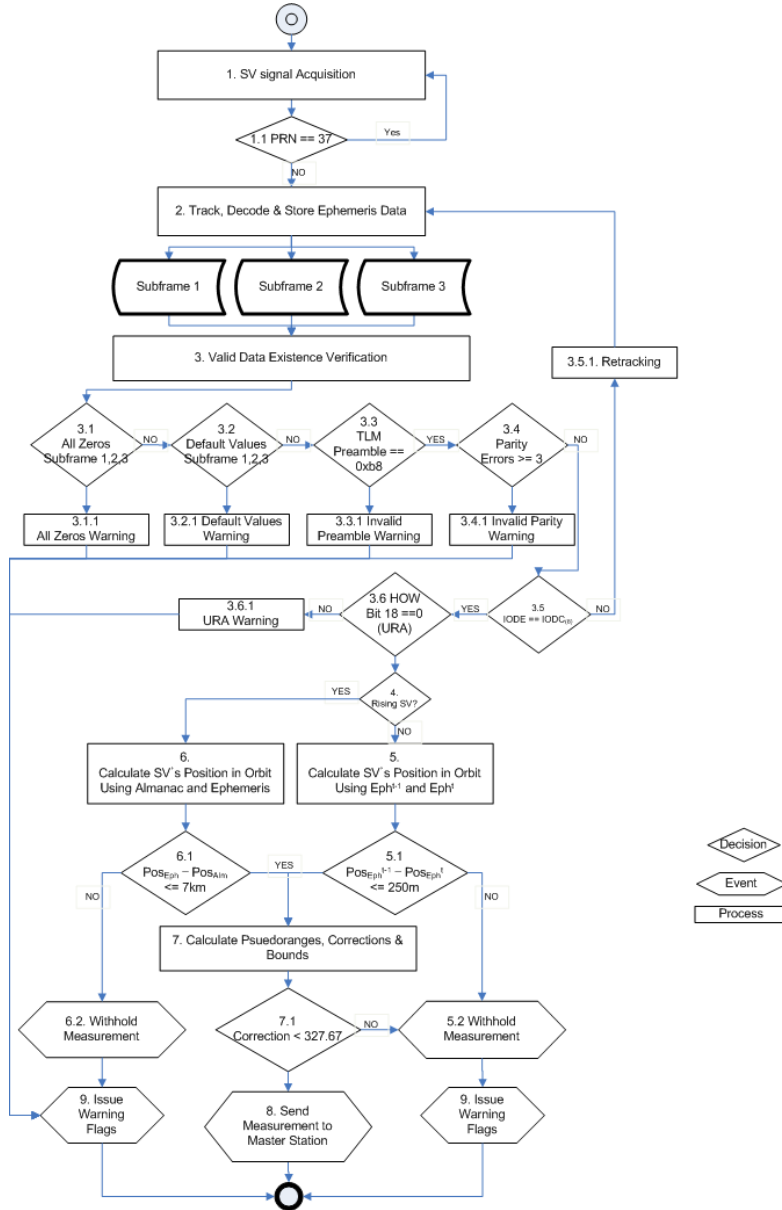
Fig 3: Data Quality Monitoring Process

Data quality monitoring is processed as in Fig. 3. As a consequence of data processing,

the following data are to be generated, and transmitted to the WMS via terrestrial communication network.

- WRS ID

- Data Status Flag

- Number of Visible Satellite

- Time of Data Reception

- Error of WRS Clock

- Measurements/Corrections for each GPS Satellite:

  PRN for each GNSS Satellite, Data Status Flag, IODE, Pseudorange Residuals, Standard Deviation of Pseudorange Residuals, Vertical Ionospheric Delay, Standard Deviation of Vertical Ionospheric Delay, Latitude and Longitude of IPP, Doppler Measurement.

4. Preliminary Design of WRS Software

WRS software is design based on Modular software design and Layered architecture to provide the flexibility of software architecture.

WRS software is divided into several independent, interchangeable and reusable components to reduce complexity and maintenance cost. The components can be added or replaced into WRS software without or with minimum affect on the rest of the components. The current software is designed to collect and process GPS data however it is flexible to accommodate future GNSS systems such as GLONASS and Galileo. The new component can be incorporated into WRS software through interfaces that express the elements that are provided and required by the component. If new component adheres to interface, it can be added or replaced without affecting other components.

WRS software also takes a layered architecture in order to provide model to create flexible and reusable software. WRS software is divided into different layers such as Data Transmission and Data Display where each layer can be easily replaced or new layer can be added without or with minimum affect on other layers.

Consequently, the WRS software is structured to be easily be extended for multi-DGNSS, and data processing models such as ionospheric correction, tropospheric

corrections etc can be easily adapted.

4.1 Use Case Model

The WRS Use Case Model (Fig.4) that shows the relationship among actors and use cases in the system. The WRS software consists of 4 actors and 17 use cases. The 4 actors are Time, WRS Operator, WRS Administrator and WMS. Among the 4 actors, the Time is a primary actor of the WRS software. It triggers an event when time interval expires or new data arrives within the system. In response to an event, several functions such as satellite ephemeris determination, pseudorange calculation, data quality monitoring, integrity monitoring, data verification, etc are invoked.

Use case diagram is generated to represent relations among actors and use cases within the system. In order to carry out the WRS function, 18 use cases are generated such as Collect Data, Determine Satellite Orbits, Determine Satellite Corrections, Determine Integrity, Determine Satellite Integrity, Calculate Ionospheric Delay, Calculate Tropospheric Delay, Calculate Pseudorange, Calculate WRS Position, Monitor Data Quality, Determine WRS Integrity, Determine WRS-WMS Network Integrity, Perform Data Verification, Transmit Raw and Pre-processed Data to WMS, Transmit WRS Information, Log data, Display Data, Configure and Maintain WRS.
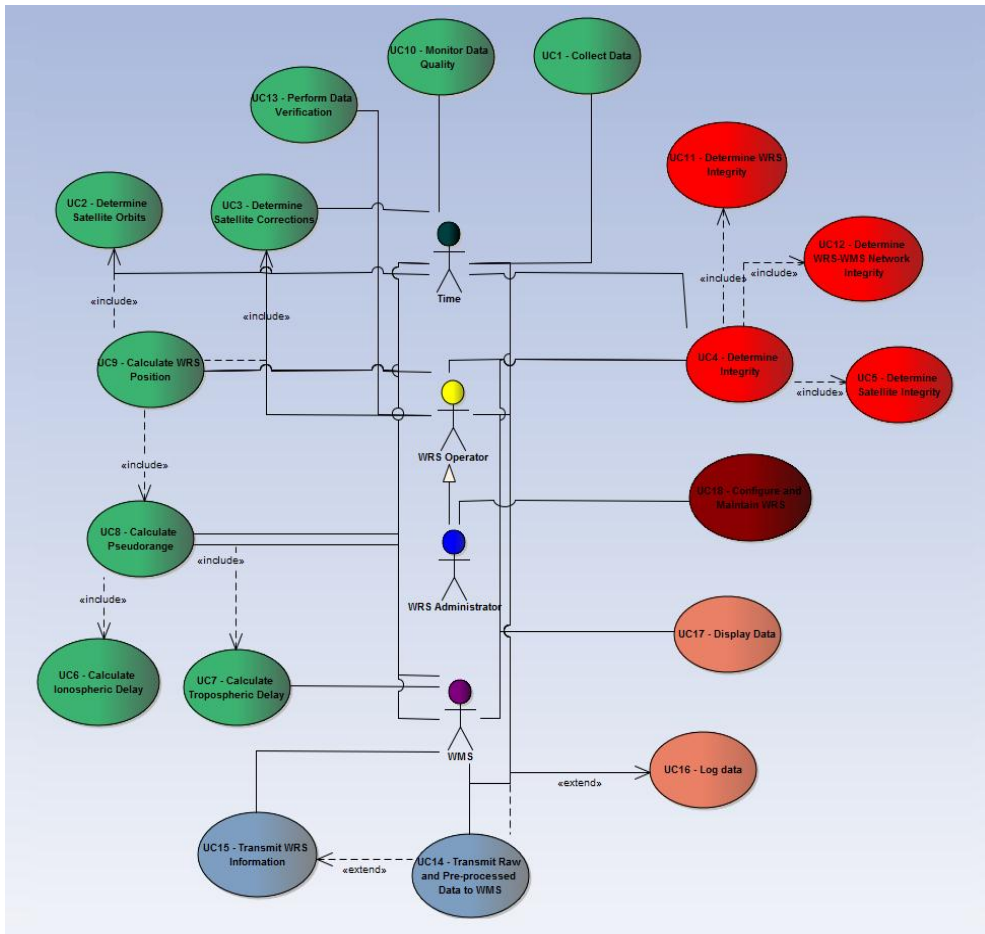
Fig. 4. WRS Software Use Case Model

4.2 WRS Software Architecture Design

WRS software architecture (Fig 5) is configured to carry out data handling, data quality monitoring, etc and the various Use Cases are to be executed. WRS software architecture comprises 19 components, some with subcomponents: Navigation Message Receiver, Navigation Message Decoder, Data Handler, Data Quality Monitor, SV Integrity Monitor, WRS Integrity Monitor, WRS-WMS Network Monitor, Data Processor, Metrological Station, SV Azimuth and Elevation Calculator, Pseudorange Calculator, WRS Position Calculator, Independent Data Verifier, Raw and Pre-processed Data Buffer, WRS Information Manager, WRS Operation and Maintenance, Data Logger, Data Display Unit,

WRS-WMS Interface Unit. For each component, task description is provided followed by the description of Input, Processing and Output.
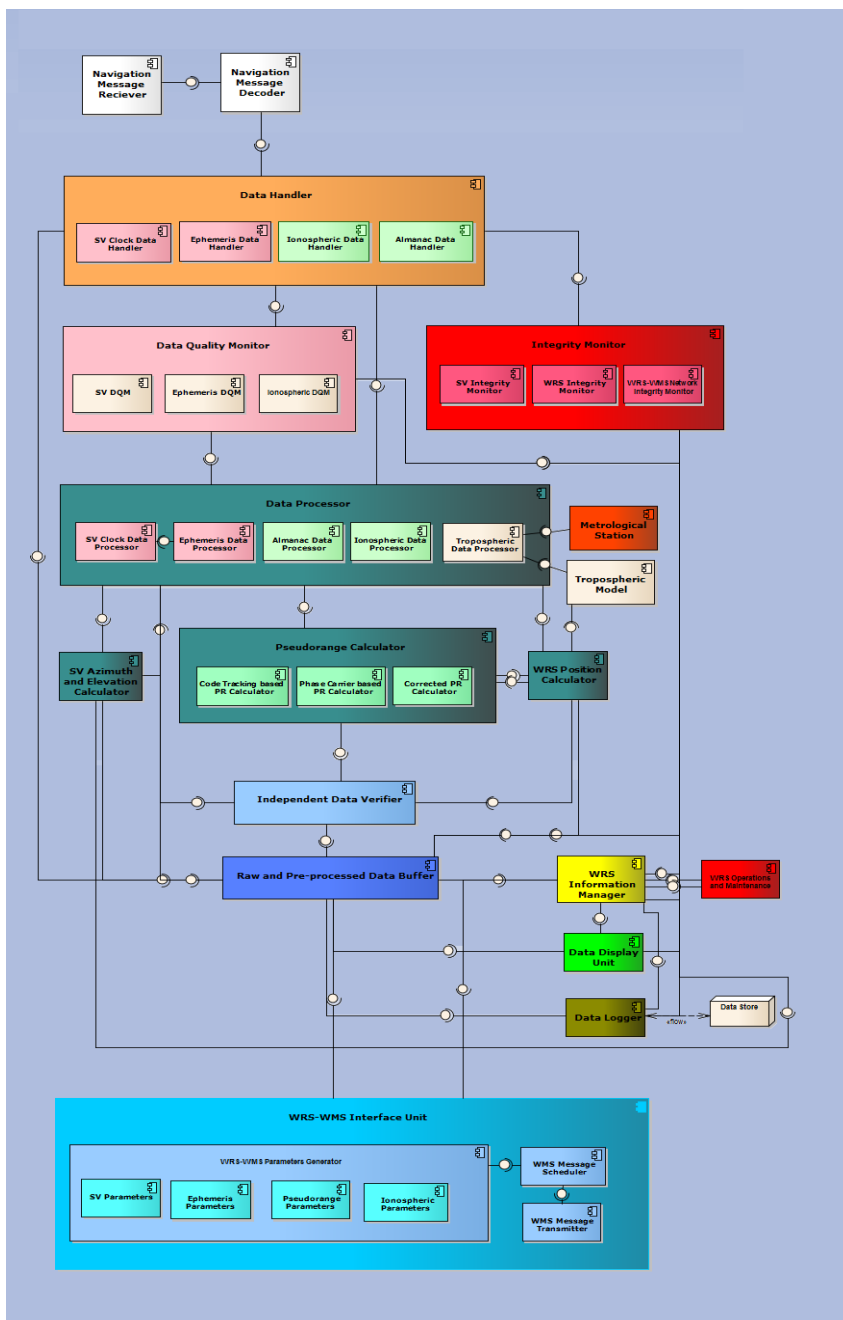

Fig. 5. WRS Software Architecture

4. Conclusions

In this paper, we described the preliminary design results for the WRS data processing of the Korea WA-DGNSS project. Data processing functions are identified, and corresponding use cases are defined for processing the WRS data processing functions. In order to adapt for future multi-DGNSS environment, the architecture design takes approache on modularity. Detailed design of WRS software will be followed by carrying out the class diagrams, activity diagrams, modeling validations etc.

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