DESIGN OF A SATELLITE DATA MANIPULATION TOOL IN A TIME AND FREQUENCY TRANSFER SYSTEM USING SATELLITES

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Abstract

Two methods are widely being used to synchronize time/frequency of a communications system. One is using earth networks, the other using satellites. In the method using satellites, a transmitting station sends the high precise time information, satellite position data,and error correction information,etc.,to the satellites. To accomplish this, the satellite data manipulation tool of a transmitting station should perform the reliable and fast interaction with other tools when acquiring, transforming, and sending data to the baseband. In this paper, we present the design and core algorithms of the satellite data manipulation tool in a transmitting station as an R & D part of the time/frequency transfer system using Koreasat of Korea Telecom.

INTRODUCTION

The time/frequency transfer system distributes time/frequency to each hierarchical level of a communications system to synchronize the wired or wireless communications system and uses an earth system or satellite system as a transmission route. In Korea, KRF (Korea Reference Clock) generated from KT[1] and KRISS[2] is distributed through an earth system using the multi-relay system. But the multi-relay system has the weak point that the precision and stability of time/frequency become worse going to a lower level. Furthermore, more precise time/frequency synchronization system is needed to provide multimedia services in next generation communications systems.

Major countries with advanced telecommunications technologies have vigorously ongoing

[1] KT (Korea Telecom)
[2] KRISS (Korea Research Institute of Standard Science)

research about the time/frequency transfer using satellites to achieve high precision and stability. In Korea, research for the time/frequency transfer system using Koreasat is in progress. The time/frequency transfer system using satellites is composed of transmitting stations, a satellite system, receiving stations, and error correction systems, and a reliable satellite data manipulation technology in a transmitting station is very important to transmit data steadily.

Therefore, in this paper, we present the method to receive satellite position data, error correction data, and time information from the satellite control station and the design & algorithm of a satellite data manipulation tool which transforms and transmits data to the baseband of the transmitting station.

DESIGN OF SATELLITE DATA MANIPULATION TOOL

TIME/FREQUENCY TRANSFER SYSTEM STRUCTURE

In Figure 1, we can see the structure of time/frequency transfer system using satellites which is to be implemented finally in our research project. The system is composed of a transmitting station, a satellite system, a receiving station, and an error correction & integrity monitoring system.

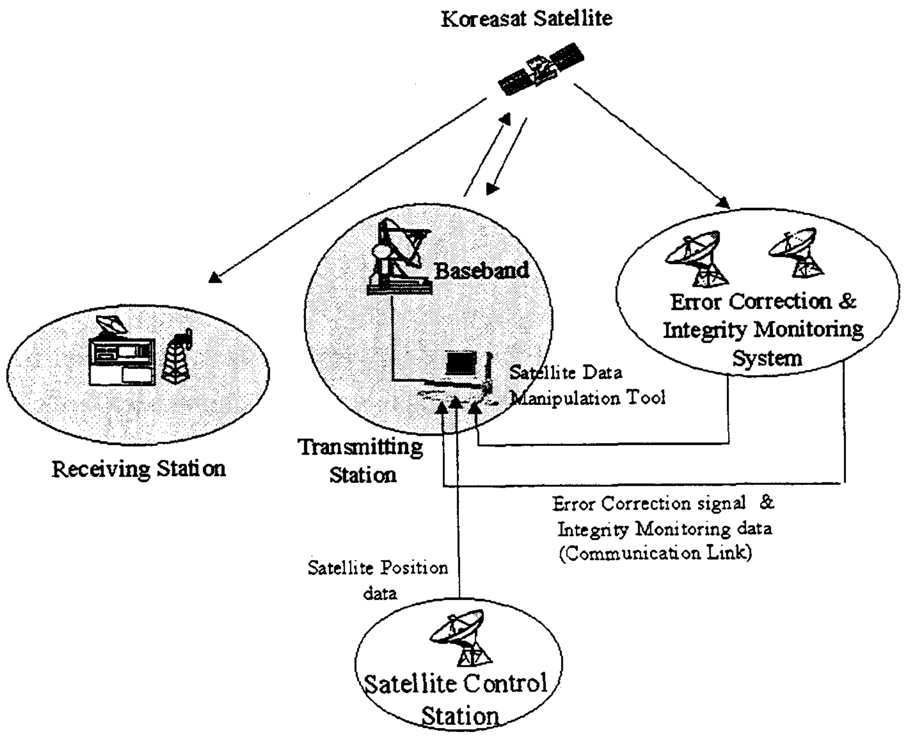

Fig. 1. Time/Frequency Transfer System Using Satellites

The satellite data manipulation tool in a transmitting station receives satellite position data & error correction data from the satellite control station and error correction data from the integrity monitoring system, transforms data into an appropriate format, and finally transmits data to the baseband part through RS-232C. The baseband part executes channel encoding and time encoding to the satellite position data such as coordinates values, velocity vector, and acceleration vector, time information, and error correction data. Finally, the baseband part transmits data to the Koreasat satellite through a Ku band antenna. The Koreasat satellite serves as a relay station, therefore simply retransmits time/frequency signals all over the country. The receiving station processes time/frequency data reflecting error correction data and provides accurate time/frequency to synchronize a communications system.

SOFTWARE BLOCK STRUCTURE

In Figure 2, we can see the software block structure of the satellite data manipulation tool. The structure is composed of 6 blocks and exchanges data with external three blocks (satellite monitoring block, error correction system block, and baseband block).

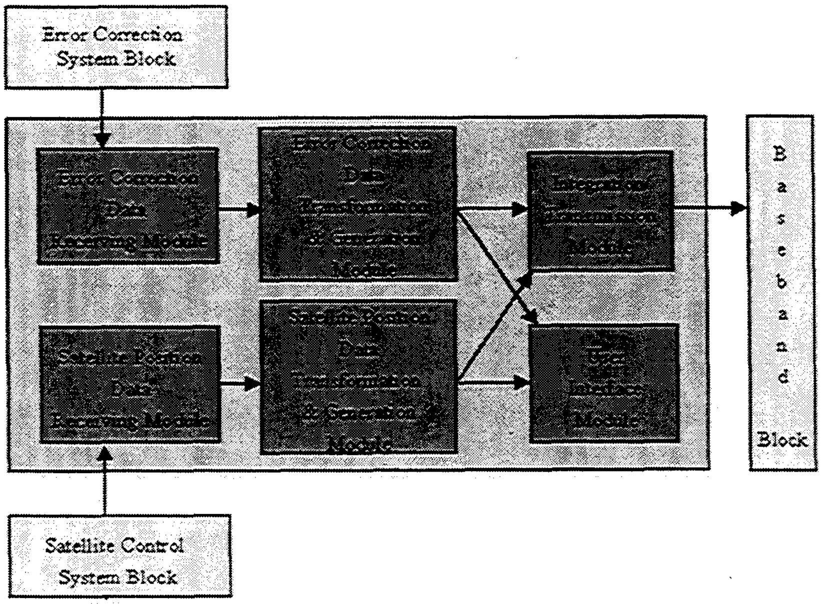

Fig. 2. Software Block Structure

The error correction data-receiving module receives error correction values from error correction system; the error correction data transformation & generation module adapts received error correction data to the predefined unit and digit number of data format and generates binary error correction values. The satellite position data receiving module receives satellite position data from the satellite control station, and the satellite position data transformation & generation module subtractseach offset from each field value of satellite position data, adapts data to the predefined unit & number of digits, and generates satellite position values. The error correction & satellite position data-integration/transmission module integrates error correction data and satellite position data into one data structure and transmits integrated data at the request of baseband. The user interface module shows transmission states graphically and friendly.

ON-LINE DATA PROCESSING ALGORITHM

On-line processing algorithm is shown in Figure 3, which is how satellite data manipulation tool receives and manipulates data from satellite control station & error correction system.

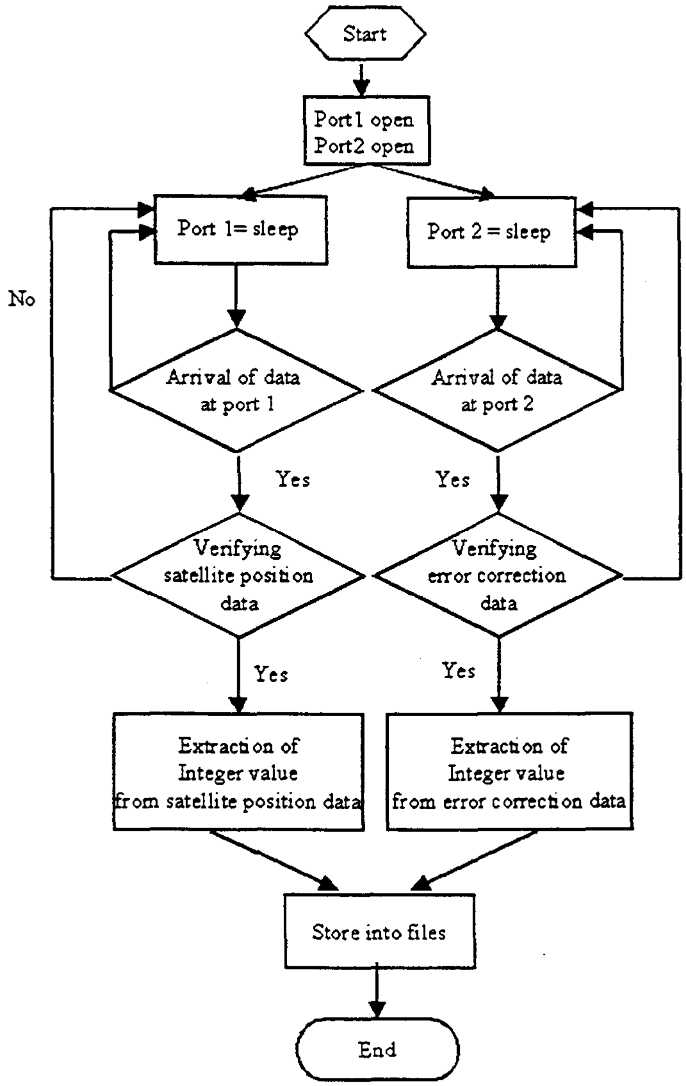

Fig. 3. On-line processing algorithm

On-line processing is essential because of periodical transmission of data from satellite control station & error correction system. After the satellite data manipulation tool is initialized, communication ports allocated to the program are opened. One port is for satellite control station and the other error correction system. The initial port state is SLEEP and does not work at all until it receives data from external blocks. When data from a satellite control station arrives at port 1, the data are verified for correctness of data format. If it is correct, after extracting binary values of the field in accordance with the standard value defined in each field of satellite position data, the tool stores the values in a file according to the data structure for transmitting to baseband. When data from an error correction system arrive at port 2, the data areverified for correctness of data format. If it is correct, after extracting binary values of the field in accordance with the standard value defined in each field of satellite position data, the tool stores the values in a file according to the data structure for transmitting to baseband.

TRANSMISSION DATA STRUCTURE

The structure of data transmitted to the baseband part from the satellite data manipulation tool is shown in Figure 4.

1 8 9 72

preamble (1bit)	subframe# (3 bit)	string# (4bit)	(64bit)

(a) String structure

1 8 9 72

String #1	Time (14 bit)	Initial time of satellite position (14 bit)	KST_offset (16 bit)	KST_offset_drift (8bit)	B
#2	Orbit info:position (x,y,z:60 bit)	B			
#3	Orbit info. : velocity (x',y',z':24 bit)	Orbit info. : acceleration (x",y",z":24 bit)	B		
#4	Time correction (TOA_1 : 24 bit)	Delay correction (TOA_1 : 24 bit)	Error correction station ID(3bit)	B	
#5	Time correction (TOA_2 : 24 bit)	Delay correction (TOA_2 : 24 bit)	Error correction station ID(3bit)	B	
#6	Time correction (TOA_3 : 24 bit)	Delay correction (TOA_3 : 24 bit)	Error correction ID(3bit)	B	
#7	Time correction (TOA_4 : 24 bit)	Delay correction (TOA_4 : 24 bit)	Error correction station ID(3bit)	B	
#8	B				
#9	Integrity (4 bit)	SNR (?)	B		
#10	Transmitting station identifier (4 bit)	Transmitting station position info.	B		

B : Blank

(b) Subframe structure

Fig. 4. Data Structure

In Figure 4(a), the structure of 'string' is shown and 'string' is defined as a transmission unit per one second. One 'string' is composed of 100 bits. Initial 8 bits mean ID, 9-64 bits are data, and the remaining 20 bits are for time marker. Preamble 1 bit is the start flag of 'string', subframe number 3 bits mean the number of subframe, and string number 4 bits display the order of 'string' in a subframe.

In Figure 4(b), the contents of a subframe structure are shown. 'Subframe' is the real transmission unit, including position data and error correction data, and one subframe is composed of 10 'string's. String #1-#3 are filled with time information & position data and String #4 - #7 error correction data. Integrity in string #9 is information related to system integrity and SNR information related to radio circumstances between satellites and earth stations. String #10 is filled with an ID and position of a transmitting station. B(Blank)s dispersed here and there are spaces in preparation for the update of data structure & additional information.

PROTOCOL FOR INTERACTION WITH THE BASEBAND

The protocol for interaction between the satellite data manipulation tool and the baseband is shown in Figure 5.

When the satellite data manipulation tool begins, it enters into waiting mode first (1). If the tool receives an ENQ signal that means requesting the data transmission (2), it checks the value of SUBF_FLAG variable (3). If the SUBF_FLAG variable is ON, it transmits data, but if the SUBF_FLAG variable is OFF, it generates a subframe (4). IF the SUBF_FLAG variable is ON, Bytecount variable, which counts the number of transmitted bytes, and ERROR variable, which counts the number of errors, are set to 0 (5) and transmits 1 byte (6). If the ACK signal that means successful reception arrives from baseband after transmission of 1 byte (7), one is added to Bytecount variable (13). Next, the tool checks whether Bytecount is 91 (14), if yes, it enters into waiting mode and waits for baseband signal. The reason why it checks whether Bytecount is 91 is one subframe is composed of 91 bytes. IF a receiving signal is not ACK, the tool checks whether the signal is NAK (8). If the signal is NAK, it means the baseband part does not receive data, so, one byte is retransmitted (9). If the receiving signal is not NAK as well as ACK, it waits a moment and one is added to ERROR variable (10). If ERROR variable is 3 (11), the tool or the baseband part is regarded as abnormal; therefore, the tool makes an alarm (12) and enters into waiting mode. If ERROR value is less than 3, it returns to validate the value of receiving signal.

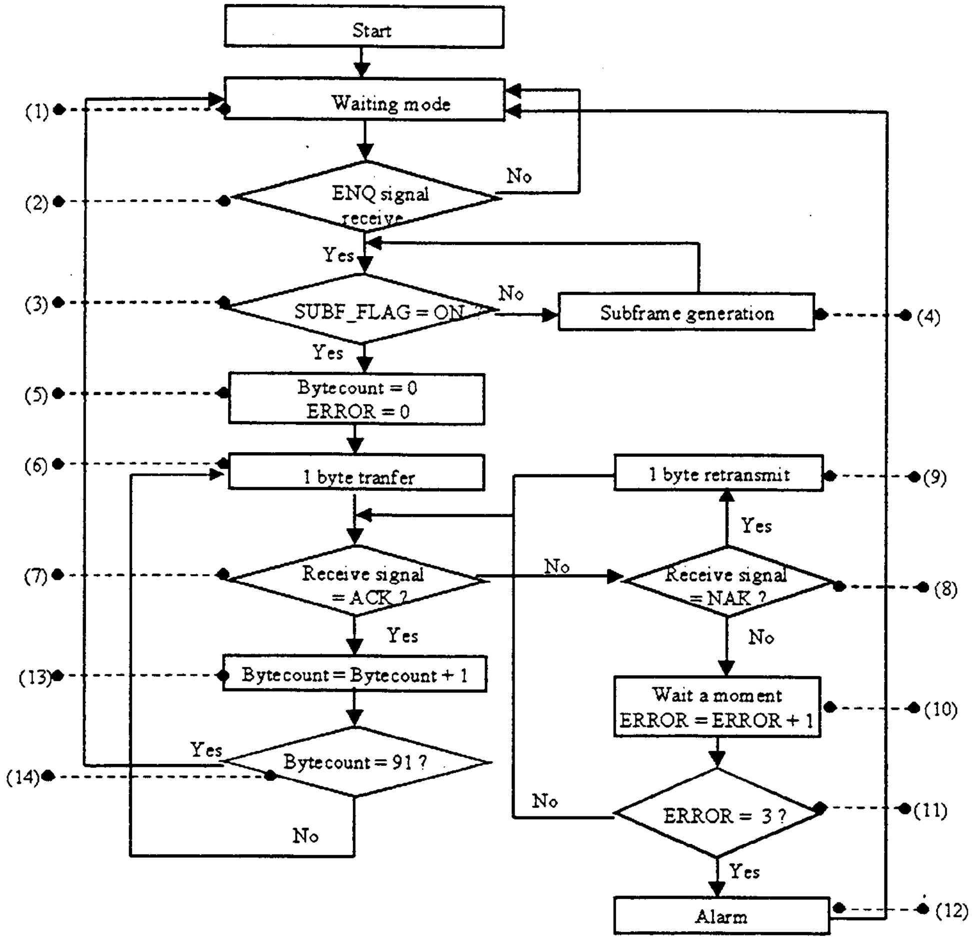

Fig. 5. Protocol between the tool and baseband

CONCLUSION

In this paper, we presented the design and protocol of a satellite data manipulation tool in the transmitting part in time/frequency transfer system using satellites. The major function of the satellite data manipulation tool is to provide reliable position data and error correction data of a satellite. The tool is designed to show users all processes of collecting, transforming, and transmission of satellite data through GUI (Graphical User Interface). Since the tool has also an additive function that easily analyzes and finds out the reason of system faults, the system performance analysis & maintenance efficiency can be improved in the future.

The design and algorithm are applied and being implemented as the satellite data manipulation tool for the project titled "time/frequency transfer system using Koreasat satellite". We have a plan to verify and improve the performance of the algorithm based on data generated through long-time experiments after system implementation.

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