TDRS KU-BAND GATEWAY

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ABSTRACT

The Wideband Transport Frame Formatter (WTFF) is the Tracking and Data Relay Satellite (TDRS) Ku-band return link gateway. This gateway is designed to support the Consultative Committee for Space Data Systems (CCSDS). The WTFF is being developed by Goddard Space Flight Center as a proof of concept project for the CCSDS and the National Aeronautics and Space Administration (NASA). This design is in many aspects consistent with the Open System Interconnect (ISO) model's "lower layer architecture".

The WTFF system is a multiplexing device developed to process and downlink the high rate data generated by a wide variety of users. The WTFF is designed to frame and format high data rate user channels into transport frames and multiplex according to a predefined schedule into two bit streams that are compatible with TDRS Ku I and Q band service. The combined data rate will be 300 Mbps. The WTFF will service up to eight input channels generating data in the range of 10 to 150 Mbps. In addition to these input channels, audio data will be accepted by the WTFF system and inserted in the downlink. A second function of the WTFF is to provide telecommunication coding as assigned to each virtual channel to ensure a given quality of service.

INTRODUCTION

The WTFF is designed to be the TDRS Ku-band return link gateway. The WTFF is a multiplexing device developed to process and downlink high rate data generated by a wide variety of users. Note that the term user in this document refers to a higher data handling unit and does not necessarily mean "end user." Also, the terms virtual channel and user channel are interchangeable. This design is in many aspects consistent with the Open System Interconnect (ISO) model's "lower layer architecture." The WTFF is a device designed to implement the link layer protocol (layer 2) and the physical layer protocol (layer 1) of the ISO model.

The output of the WTFF is tranfer frames recommended by the CCSDS (1). A functional diagram of the data flow onboard a platform is shown in Figure 1. There are several service access points into the WTFF. The first is through an onboard local area network. The second is via direct connection to the WTFF with high rate data or video data. Another access point is via an audio input channel. And finally, the WTFF is capable of receiving preformatted transfer frames produced by another system and transmitting over its TDRS link.

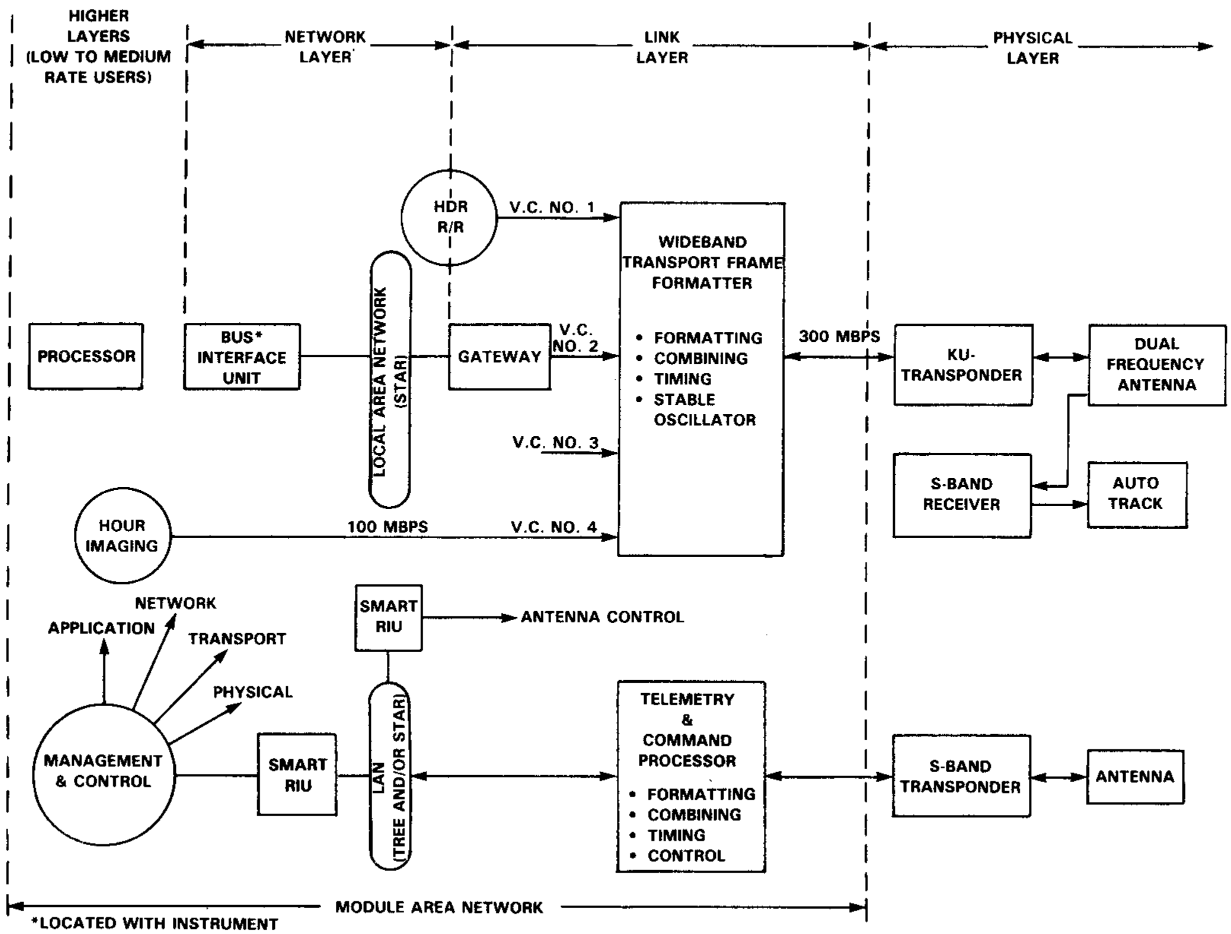

Figure 1. Functional Diagram, Platform Data Flow

Although this system is a proof of concept, some similarity to the interfaces of the actual onboard system is built into the WTFF design. One of these interfaces, is the Data Management System (DMS) and will be simulated to accomplish commanding to the WTFF and to report the status of the WTFF. Commands to the WTFF would be uplinked via an S-band link and relayed to the WTFF through the DMS local area network. The WTFF status would be output to the DMS and inserted into the data on an input channel to the WTFF connected to the DMS.

SYSTEM DESCRIPTION

User Interface

The WTFF is designed to process up to eight user data input channels each generating data at rates of 10 to 150 Mbps. Data generated by a user will be transferred into the WTFF in multiples of 8-bit octets. The WTFF will provide interface status and optionally acknowledge data reception to the user. The following data types may not be mixed within a user channel.

- A user's privately defined format either bit stream or higher layer ISO data
- CCSDS standard data packets of variable length
- Tape recorder playback of user's data

Virtual Channel Processing

Each active user's data received by the WTFF will be placed into a virtual channel block. The virtual channel block will contain an identifier to depict from which user channel the data originated along with various control fields. The virtual channel block will then be encased in a transfer frame by the WTFF for downlink.

Virtual Channel Format

The packets received from a user data channel must not exceed 4,096 bytes in length. The segmentation of the data is an option for the user. The bit stream user will have to insert frame information into the stream that will enable the ground processor to synchronize the data. The framing performed by the user will be asynchronous to the frame synchronization within the WTFF system.

Downlink Specification

The virtual channel block is encased in a transfer frame for downlink. Transfer frames from all data channels are multiplexed into a common data stream for downlink. The common data stream will be downlinked over the TDRS I and Q channels at 150 Mbps per channel. The WTFF will continuously downlink over the TDRS channels; if no "true" data is available, there will be an idle virtual channel frame transmitted. The transfer frames output to both TDRS channels will be continuously stored on separate tape recorders in circular buffer fashion. The transfer frame length will be fixed at 10,232 bits, including the WTFF frame synchronization pattern. Each transfer frame will contain only one virtual channel's data. The maximum output rate of the WTFF is 150 Mbps per output channel. The WTFF will transfer data received from each user channel in a data structure called a transfer frame.

Quality of Service

There are three qualities of service available from the WTFF. The quality of service is assigned to a given virtual channel and it is not mixed within a virtual channel.

- QOS 1 (Highest Quality)—Data guaranteed complete, error-free (within the capability of the error detection/correction utilized), and in sequence. One method of accomplishing this quality of service is by providing Automatic Report Request (ARQ) service.

- QOS 2 (Standard)—Data is delivered possibly with outages and errors but guaranteed in sequence without duplicate. This may be accomplished by concatenating the Reed-Solomon coding to the transfer frame.

- QOS 3 (Poorest)—Data is delivered possibly with outages and errors, but guaranteed in sequence without duplicate. This quality of service may be accomplished by concatenation of the CCSDS recommended 16-bit polynomial to the transfer frame.

ARQ Service — Optional

The method and procedures for providing ARQ service for users is currently under study. The WTFF will provide ARQ service to a single user channel. The ARQ service is used to request retransmission of specified virtual channel frames. The Virtual Channel Processor (VCP) would be responsible for holding frames for the specified virtual channel if a request for retransmission was necessary. The virtual channel sequence count will be utilized at both the ground terminal and onboard the WTFF to identify frames for request for retransmission. To minimize the onboard buffer requirements, the user input bit rate to the WTFF is limited to 1 Mbps when using this option. If the VCP is to provide the ARQ function for a user data channel, the VCP will remain in this mode for the entire mission. It is the task of the ground "zero level processor" to restore the transfer frame to sequencing.

Audio Data Insertion — Optional

The WTFF will accept audio data received from one source independent of the normal user data channels input and insert it into the requested virtual channel block(s). In order to accomplish in sequence restoration of the audio data at WTFF operationally high data rates, the audio data will be inserted in a single virtual channel transfer frame. At relatively low data rates, the audio data may be inserted into all transfer frames.

SYSTEM COMPONENTS

The WTFF system is shown in Figure 2 with various subystems. The WTFF is composed of the following subsystems:

- User Channel Interface (UC0
- Audio Data Input (ADI)
- Virtual Channel Processor(s) (VCP)
- Virtual Channel Multiplexer (VCM)
- Outer Code Generator (OCG)
- Frame Synchronization Generator (FSG)
- Inner Code Generator (ICG)
- Tape Recorder Storage Unit (TRSU)
- System Controller

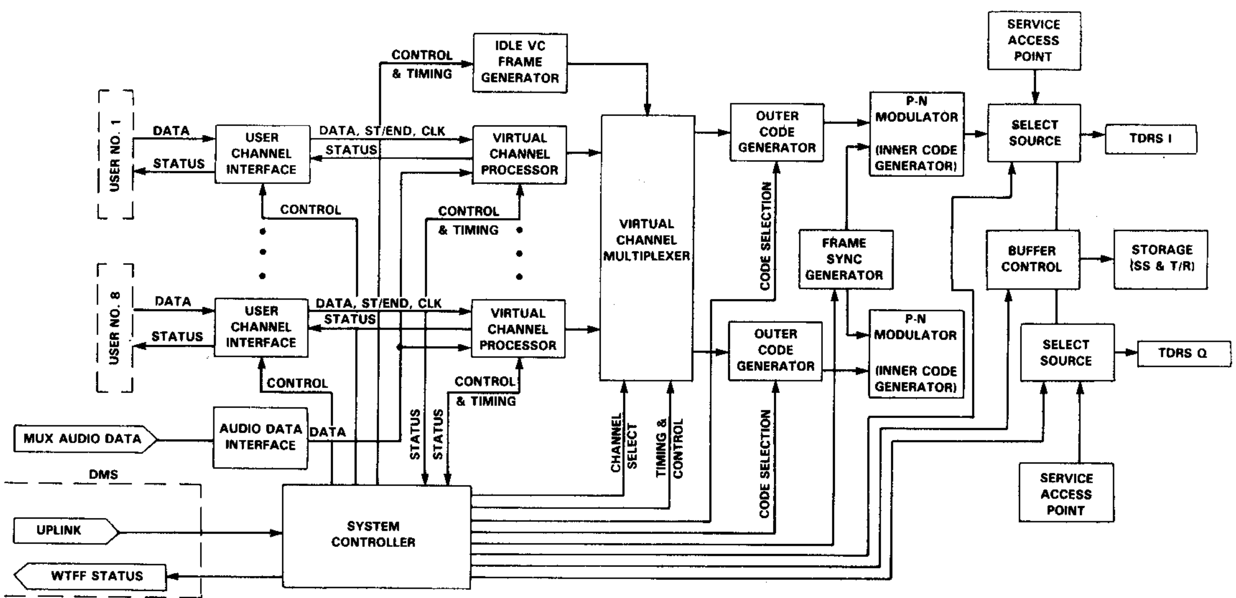

Figure 2. WTFF System Overview

User Channel Interface

The UCI is the interface between the user data channel and the WTFF. There will be up to eight UCI units in the WTFF. The UCI unit will receive the user data via an optical fiber link and subsequently output the data, start/end message signal, and a message clock to the VCP. Under consideration is an option where the UCI will transmit status to the user, (i.e., virtual channel buffer status and buffer availability) and may provide message received acknowledgment for ARQ channels. Message acknowledgment between the UCI and the user may be accomplished by utilizing the packet CRC on CCSDS packets (Ibid).

Audio Data Input

The WTFF will optionally input data from one audio data source and insert it into the appropriate virtual channel frame(s). There will be at most one ADI in the WTFF. If more than one source is required for a given configuration, the multiplexing of the input data must be done externally of the WTFF. The method of sampling the audio data is currently under study.

Virtual Channel Processor

The VCP is the virtual channel frame formatter of the WTFF. There will be up to eight VCPs in the WTFF, all identical in design and implementation to accommodate the generality of the system. The VCP receives data from the UCI and inserts the data into the data field of the virtual channel frame along with various other fields (i.e., primary header and secondary header) according to channel type. The VCP will buffer the user data for insertion into the virtual channel frame as necessary. The System Controller will transfer parameters to the VCP to identify the channel type. These parameters will determine the processing necessary for this channel.

Idle Transfer Frames

There are two instance in which the WTFF will downlink idle transfer frames.

- The virtual channel processors selected have not compiled a complete transfer frame data field under the schedule driven scheme.

- When none of the virtual channel processors have compiled a complete transfer frame data field under the schedule driven scheme.

The idle frames are generated by the Idle Virtual Channel Frame Generator. These frames would be the prescribed transfer frame format and would be assigned to a specific virtual channel number.

Virtual Channel Multiplexer

The VCM will multiplex the various VCP outputs into two output streams. The VCM accepts parallel input from the VCP until a complete virtual channel frame has been received. Presently under study, there are two different methods of multiplexing the data into the stream, scheduled and prioritized data driven. The first, schedule driven multiplexing, will allocate pre-assigned slots within the total stream to each VCP. Under this scheme, a certain VCP is permitted onto the output bus only when scheduled. If there is not data available from the selected VCP, the VCM will request an idle virtual channel frame. The former, prioritized data driven multiplexing, would utilize a sampling strategy that is a function of several factors (i.e., priority, time last sampled, and operation mode) and is currently under study. If there is not data available from any of the VCPs, the VCM will request an idle virtual channel frame. There are two methods of controlling the multiplexing scheme. The first would be via “mux select” signals from the System Controller for each sample executed. The second would be for the System Controller to notify the VCM of the sample sequence and scheme, thereby relieving the controller of the laborious duty of tracking the VCM. The sample method, priority, and schedule for the VCM is dynamically flexible.

Outer Code Generator

There are two types of outer codes that are generated by the WTFF, Reed-Solomon and 16-bit polynomial. One of these codes will be applied to each transfer frame. Upon notification that a transfer frame is available from the VCM, the OCG will begin insertion of error correction/detection codes into the frame. The System Controller will notify the OCG which type of code is to be appended to the frame. The transfer frame data field must be adequately shortened to accommodate the code applied. The OCG Reed-Solomon coder performs interleaving at a depth of five. There are two OCGs: one for TDRS I channel transmission, and one for TDRS Q channel. This code along with the transfer frame constitute what is called a codeblock, which is the output of the OCG.

Frame Synchronization Generator

There are two FSGs in the WTFF system to handle each of the two OCG outputs. The FSG will precede a codeblock with a synchronization marker for frame detection at the ground system. Each of the FSG outputs the data in parallel format to the ICG. The FSG pattern is “ACFFCID” hexadecimal.

Inner Code Generator or PN Code Generator

The ICG accepts the data from the FSG in 8-bit parallel blocks and performs the parallel to serial function and delivers the serial bit stream to the TDRS I and Q channels. The output stream is nominally 150 Mbps. The proof of concept model will not use an inner code. To ensure data bit transitions, a pseudo random noise generator modulo-2 will be added to the data stream.

Tape Recorder Storage Unit

The TRSU will record all data transmitted over each TDRS channel as output from the WTFF. The tape recorder data may be requested to be played back via a ground command to the WTFF for either or both of the TDRS channels. If the request occurs to dump the TRSU, the downlink will not be signaled as a tape recorder dump. That is, the TRSU data will not be replayed through the WTFF and tape recorder bit will not be set in the header. The TRSU must be capable of storing data for a minimum of the duration of the zone of exclusion.

System Controller

The System Controller performs the following functions in the WTFF system.

- Provides the control and timing to each of the subsystems
- Receives commands in the form of packets from an S-band uplink via a local area network (DMS) and executes the commands
- Signals the VCPs of the configuration of the channel
- Resets the virtual channel sequence counters and flush data storage within the VCPs
- Controls the VCP output sampling to the multiplexer
- Reports the configuration and status of the WTFF to the DMS
- Notifies the code generators of the code selection
- Notifies the VCP of audio data insertion on/off and length

CONCLUSION

The basic building blocks of hardware for the WTFF are currently being designed. The WTFF is modular with the capability to allow for continuing changes and upgrades. It is anticipated that this system will eventually be built with custom Very Large Scale Integration (VLSI) hardware. The WTFF will be the first system to demonstrate multiplexing ability at high data rates. Space Station era data systems will introduce high data rates in communications in which the WTFF will prove extremely useful. Testbed simulation of the instruments is currently under study for interfacing to the WTFF.

REFERENCES

1. CCSDS Recommendation for Space Data System Standards: “Packet Telemetry,” *Blue Book*, January 1987.