AN APPLICATION OF ETHERNET TECHNOLOGY AND PC TELEMETRY DATA PROCESSORS IN REAL-TIME RANGE SAFETY DECISION MAKING

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ABSTRACT

The ethernet technology has vastly improved the capability to make real-time decisions during the flight of a vehicle. This asset combined with a PC telemetry data processor and the power of a high resolution graphics workstation, allows the decision makers to have a highly reliable graphical display of information on which to make vehicle related safety decisions in real-time.

BACKGROUND

For years flight safety officers relied on tracking information provided to them by radar sources, to make real-time decisions about vehicle instantaneous impact predictions(IIP). IIP is calculated using information gained from the radar source. This information is composed of vehicle velocities, position information, pitch, heading, and time.

Radar has proven itself to be a very reliable source and is a very widely used acquisition system today. Radar is however, only as good as the person operating it, and depends heavily their ability to obtain an acquisition of the vehicle so that the radar can automatically track it throughout the flight of the vehicle. The quality of the radar system itself is also critical during the automatic tracking of the vehicle.

To compensate for the abilities of the operators and the quality of radar systems, installations normally utilize several radar sources to track the vehicle during flight. Each one of these sources are input into some processing device and allowed to compete or “vote” to become the “best” source and is displayed in some fashion for the range safety officer to observe and draw conclusions from.

THE PROBLEM

While this technique works very nicely on fixed installations, it is not necessarily the case for mobile operations. Mobile operations in remote areas generally have the support of one radar source. This creates a potential for several points of failure. The possible points of failure include bad acquisition by the operator, errors in the radar system data, and outright failure of the radar system. All of the points mentioned above could lead to disastrous results, which include destruction of the vehicle or a ground accident due to the vehicle impacting into a populated area.

THE SOLUTION

One obvious solution to mobile configuration would be to procure, integrate, and ship another radar system. While this is certainly an option, it is a very expensive and complicated one, which still possesses the failure potentials previously mentioned. Another solution is to install a guidance computer system on board the vehicle and encode its output into the telemetry downlink. This solution would eliminate the operator acquisition problem. System errors and system failure would continue to be a possible failure point. However, the IIP data from the telemetry stream combined with the IIP data from the radar source would provide an invaluable asset to a range safety officer for making real-time decisions about the vehicle by providing a cost effective redundant source of data.

THE DESIGN

The design discussed in this paper will concern itself with the data handling of the telemetry stream on the receiving end only. As stated previously, the range safety officer would benefit greatly from a visual display of IIP plots and alphanumerics information. This display would be better yet if he were able to get several radar sources and a telemetry source.

The design for retrieving the IIP information from the telemetry stream involves a generous mix of hardware technology and software development. The front end of the down link involves the antenna system and a S-band receiver. The device used to synchronize, decommutate, and allow word selection of the data was the TDPlus system (designed and developed at Wallops Flight Facility) and PC card bit sync from Veda Systems Incorporated. Ethernet was the transmission media of choice for passing the selected data to the graphics devices. The graphics device utilized for displaying the IIP plots and alphanumeric data was a Personal IRIS workstation from Silicon Graphics Incorporated.

The software developed for this system handles the reading of the selected words, calculation of the IIP, control of the timing, processing of the alphanumeric and vehicle nozzle data, and the creation and transmission of the ethernet buffer.

THE IMPLEMENTATION

The first step in the implementation of this project was to assemble the necessary hardware to synchronize, decommutate, and word select the applicable parameters for calculations and transmission.

The bit synchronization for the system is performed by a PC card bit synchronizer from Veda Systems Incorporated. The bit synchronizer is capable of speeds up to 10 megabits per second for all codes.

The TDPlus telemetry computer system was chosen to support the frame synchronization, decommutation, and word selection demands of the project. The TDPlus system designed by the Telemetry Systems Section at NASA Wallops Flight Facility consists of a four card set designed to run on a IBM PC compatible computer platform. This system is capable of synchronizing up to a 5 megabit Bi-Phase PCM stream.

The timing required for the system is handled by two PC compatible cards designed by the Data and Communications section at NASA Wallops Flight Facility. The first card processes NASA 36 time code(GMT time) and also provides an interrupt which is used to in the system to control the output of the ethernet buffer. The second card processes program time(countdown time) which is input into the ethernet buffer sent to the graphics terminal along with the GMT time.

The ethernet interface is provided using a 3c503 PC adapter card from 3Com. This card is an 8 bit card that is IEEE 802.3 standard. PC-NFS software and the toolkit from Sun Microsystems Incorporated, was utilized to perform UDP socket level ethernet transmissions between the PC and the graphics workstations.

The graphics workstations used for display is the Personal IRIS from Silicon Graphics Incorporated. The software that was developed for the IIP and vehicle nozzle displays was written and implemented by the Software and Analysis Section at NASA Wallops Flight Facility. The IIP display consists map overlays for the given area of operation, alphanumerics, predicted nominals, flight boundaries, and actual IIP plots. The vehicle nozzle display consists of four view ports containing pitch and yaw nozzle deflections, azimuth, elevation, and roll information.

THE SPECIFICS

The Inertial Measurement Unit(IMU) parameters are inserted into the PCM encoder on board the vehicle. The PCM encoded bit stream is fed to the modulation port of an S-band transmitter and radiated through an antenna back to the receiving station on the ground. Once on the ground, the signal is fed through an antenna to an S-band receiver. The receiver demodulates the signal reproducing the PCM signal.

The PCM signal is then fed into the source input of the PC card bit sync from Veda Systems Incorporated. The software supplied by Veda is used to program the card for proper synchronization of the PCM stream. The data out and clock parameters are programmed for NRZ-L and 90 degrees respectively and input to the frame sync card of the TDPlus decommutator/word selector system.

The TDPlus software allows the user to input the frame synchronization information, select words, set up executable displays, set up flags, time events, customize engineering unit subroutines, and many other functions.

The TDPlus hardware consists of a frame synchronizer card, memory card, digital to analog converter card, and a control card for the digital to analog converter card.

The data and clock streams that are fed into the frame sync card are applied to the VLSI correlator chip. If the sync pattern that was programmed into the correlator is detected in the serial data stream, a sync pulse is generated. The number of bits parameter in the frame sync table is used to generate an end of word pulse that clocks out the converted parallel data across a private data bus to the memory card. Subframe synchronization is accomplished using a unique recycle code(URC). If the word counter compares the URC position, the URC code matches, and a valid end of major frame is present, subframe synchronization occurs.

The memory card accepts the parallel data and synchronization pulses from the frame sync card through the private data bus. This card utilizes 8 Kbytes of 16 bit dual ported RAM. It is from this RAM that the user may program through an index table in the software, the words he would like to scale and display. The memory card also stores information on whether or not the individual words are marked for output to the parallel port or to the DACs and the DAC address.

The DAC controller card receives the data from the frame sync card just as the memory card does(through the private data bus). The port selection data and the addresses are passed to the DAC controller from the memory card through the private data bus. The individual data is mapped to the appropriate DAC on the DAC converter card over another private data bus.

The DAC converter card receives the 8 bit digital data from the data bus and converts it to its analog representation and made available as an output through a rear end plate connector.

The project discussed earlier only uses the frame sync card and the memory card from the system. The TDPlus software is used only for synchronization purposes and is then abandoned.

Once the system is synchronized the IIP calculation program is initiated. The IIP program reads (snapshots) the data on the memory card of the TDPlus system. The location of the word to read is dependent upon the placement of information in the PCM stream when it is encoded. The data encoded into the PCM stream on this particular project was put in as 8 bit words.

The latitude, longitude, altitude, and 3 velocity vectors are all composed of 32 bit words. Therefore, a total of 24 eight bit words had to be read. The appropriate words were then shifted into position to give 6 meaningful 32 bit words. These words are then passed to the algorithm which calculates the IIP. Within this algorithm the data is scaled and limit checked.

The calculated values are returned to the calling program where they are scaled again, reversed, and stored in an ethernet buffer. The pitch, roll, and heading parameters are treated in the same manner, but are only 16 bit words.

Timing is also read from the NASA 36 time board and the program time board. These parameters are also loaded into the ethernet buffer. The ethernet buffer is a fixed position buffer transmitted with UDP sockets over an IP (Internet Protocol) network.

As the ethernet buffer is transmitted over the network, the graphics workstations are actively monitoring the traffic with a UDP socket of their own. This particular project utilizes two Silicon Graphics Iris 4D workstations. The first workstation displays the map sets for the region in which the launch operation is occurring. This map also contains the graphical information supplied by the telemetry stream pertaining to safety boundaries, nominal IIP, alphanumerics, true position information, and information on the above mentioned parameters for several radars. The second graphics workstation is used to display azimuth, elevation, pitch, roll, yaw, and nozzle deflection information on the vehicle and its Aries booster. This information is displayed using a four view port screen and driven solely by the telemetry and timing information received via the ethernet buffer.

SUMMARY

The project described above is a unique combination of a PC telemetry data processor, graphics workstations, and ethernet technology applied to telemetry. The system gives decision makers the capability to see vehicle performance graphically and make real-time decisions about flight safety. The variations that can be developed are virtually unlimited and can be applied in several different areas of technology.