BATCH PROCESSING OF FLIGHT TEST DATA

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ABSTRACT

Boeing's Test Data Retrieval System not only acts as an interface between the Airborne Data Acquisition System and a mainframe computer but also does batch mode processing of data at faster than real time. Analysis engineers request time intervals and measurements of interest. Time intervals and measurements requested are acquired from the flight tape, converted to first order engineering units, and output to 3480 data cartridge tape for post processing. This allows all test data to be stored and only the data of interest to be processed at any given time.

KEY WORDS

Batch Processing, Remote Job, Data Acquisition

INTRODUCTION

The Boeing Flight Test Data System is centered around a large mainframe computer. Test planning, data processing and maintenance records information are all stored on this machine. This paper discusses a subsystem of the mainframe computer called the Test Data Retrieval System (TDRS). The TDRS is a large data store for all Flight Test data. The test data are recorded on magnetic tape during testing and sent to the TDRS at the conclusion of each test. Analysis engineers are then able to access specific data of interest via the mainframe computer. It is important to remember that this is a post test system used to distribute test data. Real-time data analysis is done during the test on the Airborne Data Analysis and Monitor System.

REQUIREMENTS

Boeing Flight Test does three types of testing. The first is certification of new model aircraft. A single aircraft may record up to 9000 measurements per test. And three or four aircraft may be used concurrently to complete all testing in the time allotted. The
second type of testing is of new pieces of equipment or new aircraft systems to be installed on a certified aircraft. This requires the recording of up to 3000 measurements and may involve one or more aircraft. The third type of testing is of aircraft that are in service. This type require the recording of only 100 or less measurements but for long periods of time. Normal test duration's are from one to twelve hours. A twelve hour test can generate a maximum of 216 Gigabytes of data. Requests for data not only include the current days test but often are for tests up to sixty days prior. There are about ninety analysis engineers needing access to different tests and times. The analysis engineers are analyzing data in more detail than the real-time system allowed or creating reports and plots to supply their customers. With these kinds of requirements keeping all data on line would create a very complex and expensive data storage facility. Currently the data is recorded on analog instrumentation recorders. The tape is then stored in the TDRS for playback when needed. During peak testing the TDRS is operated 24 hours a day, 7 days a week. The acquisition hardware is computer controlled and communicates over a Ethernet network. Requests for data allow up to 1500 measurements and support measurement type processing, engineering units conversion, and algorithm programs. Playback of data must be faster than real-time to support processing of 160 or more request per day. Depending on the jobs priority the data must be available to the requesting engineer in either four, eight, or twenty four hours.

TEST DATA RETRIEVAL SYSTEM ARCHITECTURE

The TDRS is made up of many different data acquisition systems each controlled by a computer as shown in Figure 1. All systems communicate over an Ethernet network. The TDRS Job Distributor is a DEC VAX 6310. It is the central communications hub for all remote batch jobs entering and leaving the TDRS. It receives the batch job and processes it to determine which acquisition system to send the job to. When the job has finished it returns a completion message to tell the mainframe computer it can continue its processing. There are four different types of acquisition systems listed below in chronological order from newest to oldest. Each system was purchased about ten years apart and with each new system the speed and processing power increased significantly.

PARALLEL MULTIPLEXED PROCESSING DATA SYSTEM

The newest system just procured for the 777 program is called the Parallel Multiplexed Processing Data System(PMPD). This system is a DECsystem 5500 that
controls four Loral Instrumentation 550 data acquisition systems. Each 550 data acquisition system includes:

1  System Controller.
1  Arbiter/Analyzer.
1  24-bit Decoder.
2  Field Programmable Processors.
2  Small Computer System Interface (SCSI) controllers.
1  Ethernet Processor.

Also included in the PMPD System are:

2  Ampex Digital Cassette Recording System(DCRSi).
4  Exabyte EXB-8500 8mm Cartridge Tape Subsystem.
4  Fujitsu M2481 Cartridge Tape Drives.
MULTI-TAPE MULTI-TRACK SYSTEM

The system used for flights flown between 1980 and 1993 is called the Multi-tape Multi-track System (MTMT). This system is a DEC 11/70 processor that controls a EMR Telemetry Front End which includes:

4 Analog wideband magnetic tape drives, associated tape search units, and time code translators.
1 Analog switch matrix.
6 PCM decommutation streams with associated I/O Channels.
6 ARINC 429 decommutation streams with associated I/O Channels.
1 Data Compressor/Preprocessor with associated I/O Channels.
1 Status/Time/Interrupt Selector.
4 9-track 1/2 inch tape units.

PORTABLE AIRBORNE DIGITAL DATA SYSTEM

A third system used for small projects or aircraft in service is called the Portable Airborne Digital Data System (PADDS). This system is implemented in software on the DEC 11/45 of the STST system and includes:

1 3M HCD-75 High Capacity Data Cartridge Drive System.

SINGLE-TAPE SINGLE-TRACK SYSTEM

The oldest system is called the Single-Tape Single-Track System (STST) which is used for retrieval of data from flights flown before 1980. This system is a DEC 11/45 processor that controls a EMR Telemetry Front End which includes:

1 Analog wideband magnetic tape drive, associated tape search unit, and time code translator.
1 PCM decommutation stream.
1 Programmable Data Distributor and computer I/O channels.
1 Analog switch matrix.
1 FM-multiplex discriminator, sample/hold, analog-to-digital converter system for two sets of IRIG proportional bandwidth channels 2 through 11.
1 9-track 1/2 inch tape unit.
REMOTE JOB FLOW

Flight Test Analysis Engineers request data from the mainframe computer. The mainframe computer collects the information from its databases needed to process the request, and launches a "Remote Job Entry" batch job to the TDRS. All job files are received by the Job Distributor. The Job Distributor maintains a queue of all jobs in the TDRS and which acquisition systems they are running on. After preprocessing the database information and evaluating system loading, the job is sent to the appropriate acquisition system queue. The Acquisition system controllers then processes the job information to create setup files for the acquisition hardware and control files to control the peripheral devices. When it is the jobs turn to run, setup files are sent to the acquisition hardware and a system operator is prompted to mount the correct flight tape on the input drive and a new output tape on output drive. The system controller then commands the input drive to search for the start time of the job. When the start time is found the system controller then starts the acquisition system, input drive, output drive, and monitors the status of each device. When the end time is reached the system controller stops the acquisition system and tape drives, tells the system operator if there were any errors during acquisition that it could not resolve, and sends a job completion message to the Job Distributor. The Job Distributor in turn sends a job completion message across the "Remote Job Entry" link to the mainframe computer telling it the output tape number for that job. After the output tape is transferred to the mainframe computer it is processed with any post acquisition procedures requested by the engineer. It is then printed and distributed to the requesting engineer or saved for access across the network.

DATA ACQUISITION PROCESSING

Data coming into the Acquisition Hardware will follow a data path through the following processes: Decoding, Time Processing, Data Gathering, Algorithms on Raw Data, Measurement Type Processing, Engineering Unit (E.U.) Conversion, Algorithms on E.U. data, and Output Processing. The decoding process will demultiplex the data streams and pass the requested data. The time is checked for validity and tagged for further processing. Next, the data gathering process accumulates the proper data words of a multi-word measurement. Algorithms, if any, are then applied to the raw data. For a job requesting raw data output, tag, time, and data words are formatted and passed to the output device. For an E. U. data job, the data is then formatted by its measurement type to prepare it for output or conversion into Engineering Units. Algorithms on E.U. data are optionally performed, output processing is performed, and finally tag, time, and data words are formatted and passed to the output device.
CONCLUSION

Boeing Flight Test records large amounts of data during testing of it's commercial airplanes. The recorded test data is used by many different analysis engineers each looking at different parameters and different times during the test. By using a mainframe computer to store a large database of test parameters and running computational analysis of only the data of interest reduces the workload of the mainframe and yet allows quick access to very large volumes of data.

REFERENCES