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The SoftDecom Engine

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Abstract:

The software decommutator was recently fielded at White Sands to address the requirements of a new missile test program. This software decommutator is rewritten as a simple C program Function or Class with a simple interface. The function and an Interface Control Definition (ICD) comprise the SoftDecom Engine (SDE). This paper addresses how an SDE can deliver Enterprise Wide Portability, not only that of the SDE, but more importantly a test program's Verification & Validation (V&V).

The crux of the portability issue is reduced to defining the interface of the SDE. In the simplest manifestation only two interfaces are needed and one is a given. The input structure is defined by the telemeter minor frame with time appended if desired. The output structure is no more than an array containing the parameters required. The ICD could be generalized into a standard for most applications, but that isn't necessary, as the structures are simple, hence easy to adapt to anyway.

This new paradigm's importance will flourish on industries irreversible migration to faster and more complex telemeters. The paper reviews the relative ease that software exhibits when addressing very complex telemeters. With confidence it may be said " if the telemeter format can be described in writing, it can be processed real time". Also discussed are tasks that normally require specialized or customized and expensive equipment for example, merged streams, complex simulations and recording and reproducing PCM (sans recorder). Hopefully, your creativity will be engaged as ours has been.

Background

What began as a digital infrastructure migration at the Telemetry Data Center, became an extensive modernization of the architecture and in particular the system integration. These improvements morphed the TDC into an integrated Telemetry Data Center or iTDC. The modernization only recently got off the ground, the hold-up was the best source switch technology. Consisting of an analog histogrammer that automatically switched to the source exhibiting longest contiguous frame synchronization history. The box was designed and fabricated by White Sands personnel and designed to provide Flight Safety Officers with any available telemetry data, though it might contain interruptions, degradations and temporal discontinuities. Unfortunately no commercial devices were found that performed as well, excluding space diversity combining, not possible at White Sands.

A “White Paper” on a compositor based on real time correlation was written and circulated to spur development. A Correlating Source Selector™ (CSS™) was successfully demonstrated at White Sands by the NetAcquire Corporation. The device outperformed the analog device except for latency. The digital migration began and the analog signal handling infrastructure was mostly replaced. The interesting lessons learned are discussed in closely related papers, listed in the reference section.

Software Decommutation

Soft decommutation had been performed on an IBM 360 mainframe but gave way to hardware decommutation. It was cheaper, faster and the preferred method providing real time processing for Go/No Go evaluation and for Flight Safety decisions. Soft Decommutation remained on workstations performing post test data reduction. Though dated the work stations were very reliable and fast enough. One application, a missile reduction program that ran for several minutes was was ported to an Apple G5, the recompiled reduction ran in less than two seconds causing us to believe the program had simply crashed. The directory was inspected and the finished data file nearly a hundred megabytes in size was found. An inspection of the file verified that indeed, all the data had been processed. At that point we realized ‘real-time’ software decommutation could be implemented on an inexpensive desktop microcomputer. The only obstacle was getting the telemetry data into the computer in real time.

The Data Bridge

Sometimes its just your lucky day, it turns out the same CSS device that generates a best source would also readily take PCM encoded data and generate minor frame aligned packets over IP. The CSS could place the data on the network in real time, at fairly high rates and conversely, receive a packet containing a minor frame of data from the network, and clock it out as PCM. The utility was immediately recognized and a PCM simulation was successfully generated for a target vehicle. It was easy to realize considerably more complex simulations than our hardware simulators could replicate. The Data Bridge capability provided the data directly to the G5 computers over Ethernet. The received minor frame and appended time then logged directly to disk, processed and displayed in real time.

The ready availability of computer friendly, minor frame aligned network packets enable a rich and flexible net-centric architecture. The result is a drastically reduced core architecture, depicted in figure 1 composed of only two elements, the Correlating Source Selector (Data Bridge) and the integrated Decom/Display (iDD). A nominal configuration might consist of multiple CSS's driving multple iDD's.

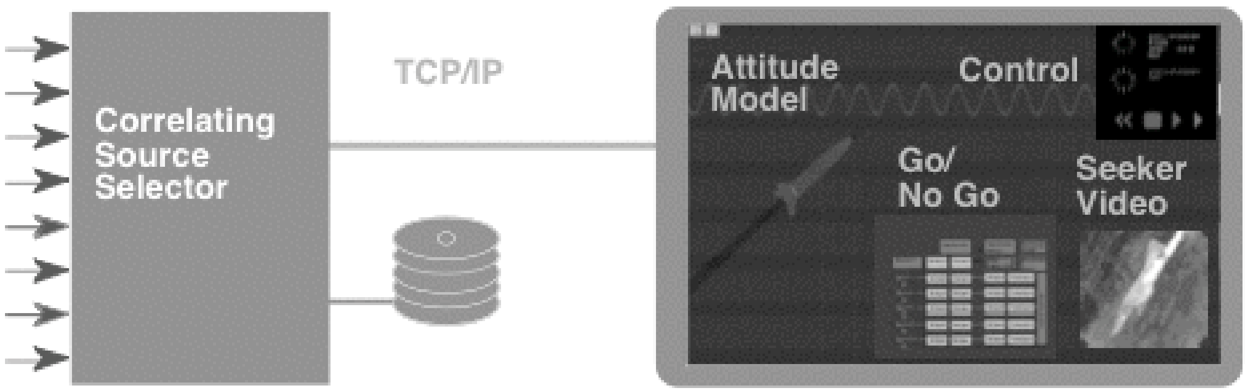

Figure 1. iTDC Core Architecture

Baptism of Fire

Developing our own software resulted benefits that were not anticipated such as the relative ease that complex telemeters may be handled in C. At White Sands, this was precipitated by a new project employing a very complex and high data rate telemeter. As a contingency the complex portions of the telemeter were processed in software on the Apple G5 computer.

It took no longer to write the C code to handle the complex tasks than it did to write the hardware databases for the normal processing. Despite that the software decommutator program was in its infancy, the additional flexibility made the task easier and hence took less time to write. When the primary hardware solution could not readily process the complex portions of the telemeter, it was displaced by the contingency solution.

Point of No Return

The writing is on the wall for the PCM hardware paradigm, the iTDC's architecture will eventually be net-centric with few PCM devices. PCM devices will eventually be relegated to the field acquisition sites.

It should be noted that excellent test direction enabled our group to find these solutions. The excellent technical disclosures and documentation were provided well in advance. Without this, there would not have been any latitude to think things through and develop what we felt was a good solution. Accurate documentation, frequent technical exchanges, follow on testing, much proofing, final article integration and rigorous data reviews are the test paradigm. Programs that elect to be less rigorous subject their testing to greater risk and often must repeat their missions and at times lose critical data if not the test article.

Paradigm Lost

If a missile program develops a SoftDecom Engine to perform the telemeter data processing, then the unabridged V&V need only be accomplished once. Since the SoftDecom Engine is developed along side the new missile, it is resident for all the V&V tests the missile is subjected to, and so the SDE too is validated. This V&V normally would be repeated to a large extent on every range that the missile might test in. For very complex telemeters this could mean many months resulting in many dollars spent and a substantial schedule impact just to repeat the V&V. But if an SDE was written, it maybe emailed along with the Interface Control Definition to the testing destination. The host Software Decommutator program then is adapted to accommodate the new ICD (or conversely the SDE interface maybe adjusted to accomodate the host software's interface) and development is done. So, is most of the V&V, only a little more than verifying the output structure mappings will be needed and V&V is done. Many months of database development, repeated testing and V&V are circumvented. Implemented at the inception of a new telemeter design, SDE's can result in substantial savings, reduction to mission risk and minimized test schedule impact.

Recorder paradigms are also at risk here. If the Chapter 10 standards compliance is bungled and doesn't result in an environment similar to the Wideband II standard, there will be no reason for Chapter 10 devices at all. Chapter 10 recorders are fairly crippled since the data isn't frame or even byte aligned when recorded. This forces all user's to procure a similar recorder to reproduce the data and a PCM Decommutator to make the reproduced data computer friendly. The Chapter 10 file itself is essentially useless. It makes more sense to log the minor frame itself along with time. The file is computer friendly and may be used directly.

As an added bonus, iTDC programers have provided a paper on a clever software application that generates time code using a computer and a Data Bridge. The paper will be in this years ITC proceedings and is listed in the reference section. With this program, the G5 or any other computer may read the time tag from the log file (or from the keyboard) and generate an IRIG B DC time code via the Data Bridge. Performing this concurrently while generating PCM data from a simulation or a log file, allows the G5 and Data Bridge to (a limited extent) replace a Chapter 10 recorder and a simulator outright. The software is also useful in stand alone uses, like testing Time Code devices, latency measurements or for making real time adjustments to the IRIG time code reference.

SoftDecom Engine Function

The Software Decommutator was originally written as a contingency, so the coding contained many programming sins of expediency. The rewrite will correct all of the sins eventually, and will provide the engine depicted in following figure (Fig. 2). The SDE function was devised to meet the requirements of the Common Frameworks Architecture technology plan at White Sands. Intended to enable any Instrumentation console with access to the telemetry net to use the data in real time as practical (i.e. tracking aid, event monitor, real time data fusion). The SDE delivers the requirement and more.

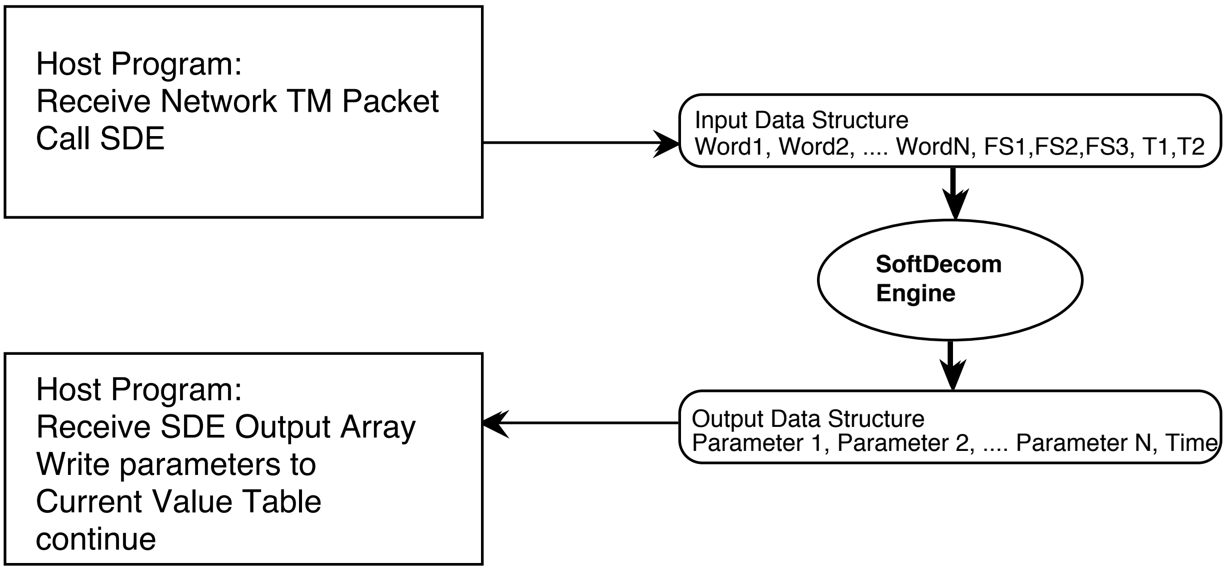

Figure 2 Basic SoftDecom Engine implementation

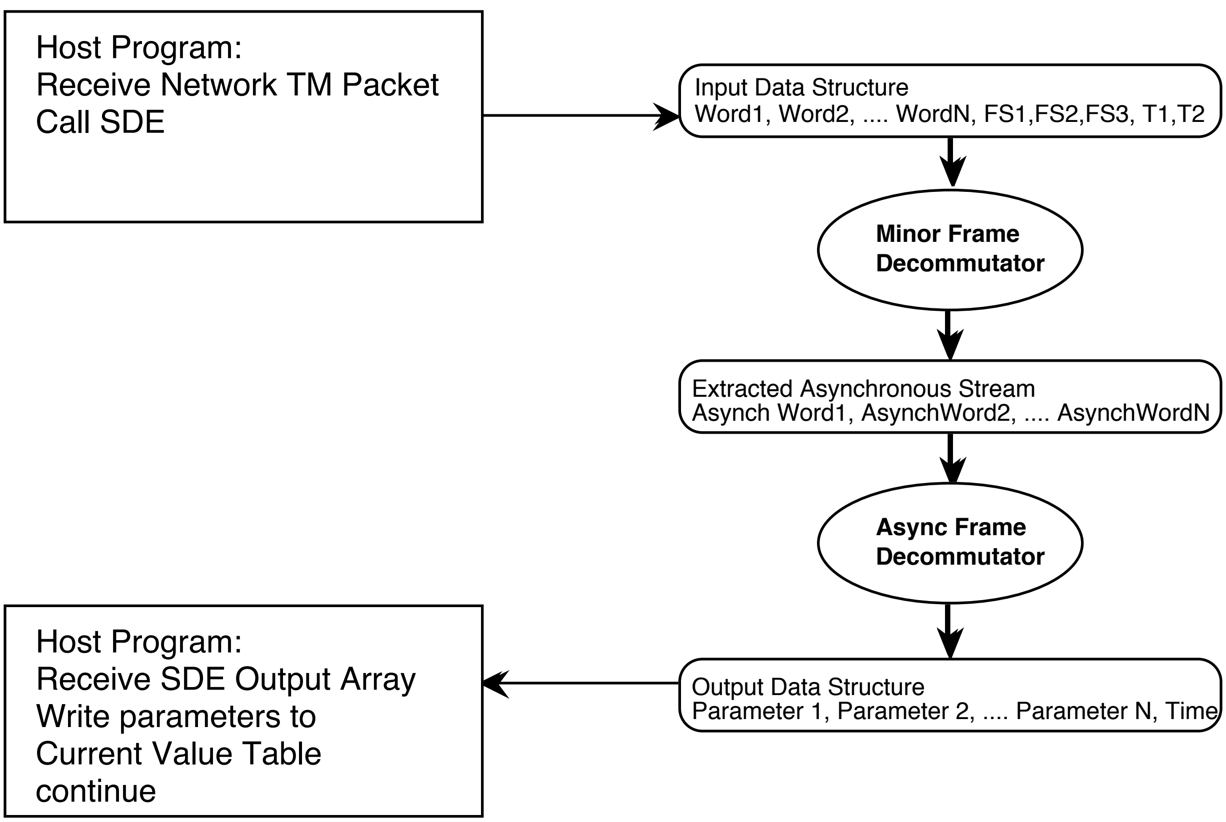

Figure 3. Asynchronous Embedded Stream Processing

The SoftDecom Engine may be written as a function, class or a process and thread friendly. The interface may be very simple, an input array and an output array are all that are needed. The engine might be dynamically allocated as many times as necessary to do the job. Complex telemeter schemes decompose into simpler “instances” and the same method will process several telemeters and merge the data in real time. The engine might be “hard” coded, resulting in a small amount of code (email size) or it may be generic in nature using a third interface structure (usually a table) that communicates the decommutation requirements to the SDE. The table may be edited without recompiling the SDE. Normally, hard or embedded coding is frowned upon, but the SDE’s are generally quite small and relatively simple. As such, hard coding is tolerated, so long as some effort is made to make the source code small and easy to read.

Data is aligned so frame synchronization on embedded or asynchronous streams is straight forward. The engine itself can be engaged numerous times to process each derivative stream independantly. An SDE may be allocated as needed for each stream, hence the simplicity of the individual SDE is maintained. Any application may call the SDE so long that the Interface Control Definition is accommodated. In Figure 3 the output record of the first SDE becomes the input record of the second SDE. Figure 4 depicts stream merging, commonly referred to as “Strip and Ship”. This type of processing is analogous to multiplexing.

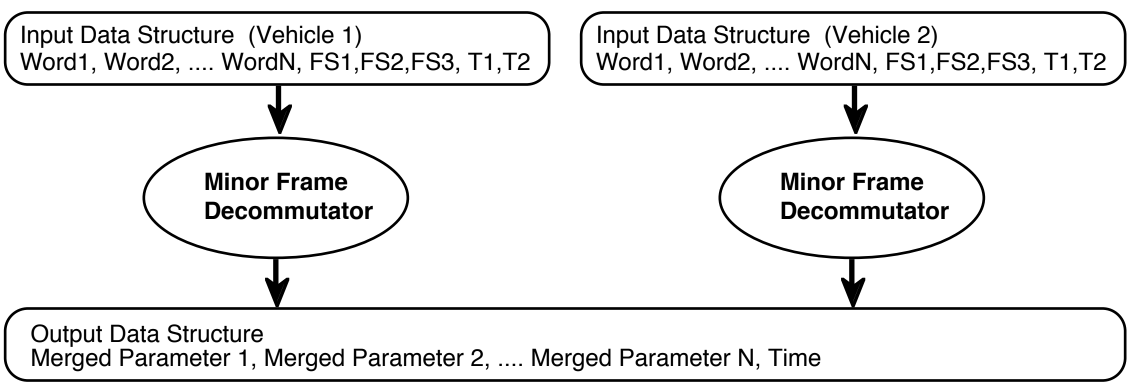

Figure 4 Multiple Stream Processing

The ICD is so simple that it may be easily altered to fit the host application, this gives the engine a sort of “Plug In” functionality, that could be resident in any device, such as a Strip Chart Recorder. This functionality would reside nicely in a Disk Recorder able to record aligned data as well. Recording merged data is feasable, a sort of poor man’s multiplexer.

Conclusion

Lack of portability is a nuisance, but promises to be a serious problem as telemeters continue to become more complex. Standardizing on a single hardware decommutator would solve the portability issue, but is there a “one size fits all” decommutator anywhere? Supposing there was and hardware decom’s were portable such that one could email the decom anywhere one needed. What would need to be standardized for this to work? The interface of course, the input would be PCM - NRZL and the output might be +/- 10 Volts DC, (DAC Range) for analog Strip Chart Recorders. So far this is easy, and it would work. This is the hardware analogue of the SDE.

The basic elements needed to apply an SDE in your application are probably already in existence at your own facility. This method spawned creative solutions to other very pervasive problems at White Sands. Please feel free to contact us regarding this discussion, we are confident you will find interesting and creative solutions as well. The papers referred to in this paper, are listed along with closely related papers. The authors maybe be reached at benitezj@wsmr.army.mil, guadianaj@wsmr.army.mil, torresm1@wsmr.army.mil and Larry.Creel@US.Army.mil. Larry Creel, Alexis Telemetry Inc, is under contract to the Systems Engineering Branch, White Sands Missile Range.

Related Technical Papers:

Digital Data Distribution	Richard Engler,	ITC 2006
!a_waste_of_time	Larry Creel, Miguel Torres	ITC 2006
Soft Decommutation and Integration	Juan Guadiana, Jesus Benitez	ITC 2005
RealTime Multiple Source Compositing	Juan Guadiana	MAES 2004

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NetAcquire Corporation