BSS with Heterogeneous Ethernet Sources

J. MALIVERNEY

NEXEYA Telemetry Skill Center

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Abstract

Nowadays, Telemetry Ground Station over a Range are all connected through Ethernet. Telemetry data can be dispatched from that layer to the Main Control Room. Nevertheless, Ethernet Protocols are so opened that the data transmitted can be heterogeneous (Throughput Ch10, Unpacked /Packed Synchronized data, PCM over Ethernet…). This paper describes an architecture based on a three layers software (Proprietary Layer, Software Frame Sync, and BSS) to manage BSS with these heterogeneous Ethernet sources. The assets (Test Range flexibility, low cost, easy upgrade) & the backwards (Encrypted data mismatch) with practical cases are also described.

Introduction

Since more a decade, Ethernet link transition has been done on board and on ground station. Dedicated protocols have been developed based on Ethernet communication (ARINC 664, AFDX, IENA and INET, IRIG 106 Ch7…). Telemetry Range with distributed architecture are connected through Ethernet network and Analog signals have been reduced to the minimum length. Ethernet assets is obvious: Standard cable connectors, worldwide protocol for data transfer from & to anywhere. That has been a great chance to reduce the cost of the telemetry installation with distributed architecture.

Large Telemetry Ranges with several remote site have to proceed to Best Source Selection to ensure to have in real time the best telemetry stream at any time and at any position of the target to follow. To do this, it is required to concentrate all the telemetry streams to the Telemetry Data Center. Installations have evolved from Analog signal transmission to Ethernet transmission through mux / demux equipment. Nowadays, Ethernet networks have been a great improvement to share data between the different sites of wide ranges.

Telemetry systems dispatched over a Telemetry range are not always provided by the same manufacturer. Due to System obsolescence and cost effective constraint, Telemetry Range system upgrades could be done with different providers at different time. Nevertheless, BSS has still to be done from any Antenna on the range. Currently, Most of the TGS equipment (receivers, decom stations) provides Ethernet outputs. However, the Ethernet protocol is not always following a standard and can be based on a proprietary Ethernet format. BSS, which has to manage all these Ethernet streams, needs first to standardize the inputs in a common data format before proceeding to the Best Source Selection Algorithm.

PCM Ethernet Streams Description:

Ethernet is a wide world with open protocol and data format. This is the same with Ethernet PCM streams, different data normalization are available. This section introduces the Major cases.

Here is the standard format of a PCM Ethernet Message:

Figure 1

IP/UDP header will not be explained here; only payload has interest. It is generally formatted according to manufacturer's Telemetry receiver, or following a standard (UDP Ch10, Ch7, iNet, PCM over Ethernet…).

Generally, the UDP payload consists in the following data:

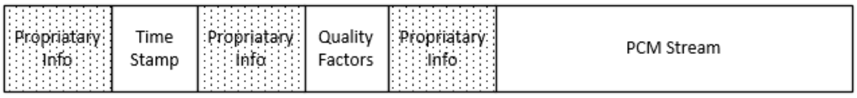

Figure 2

Common PCM Information:

- The packet Timestamp
- The quality factors (if provided)
- The PCM stream

Packet Timestamp is mandatory as Ethernet is non-deterministic protocol. Therefore, The Ethernet source of the PCM stream needs to have timestamped the packet before sending it on the Network.

Quality factors also depends on the Ethernet Source. These information depend on the ability of the receiver. Generally, we have to deal with AGC, Eb/N0, and Lock Status.

Finally, Each Manufacturer sends the PCM data stream in a dedicated format with its own positioning & its own format (integer, float, double format…). It is then necessary to apply the right process to extract all the required information.

Three possibilities of PCM stream transmission are possible through Ethernet:

- Unpacked
- Packed
- Throughput

Unpacked mode is a synchronized data flow with PCM word set on a 16-bit or 32-bit word container with additional padding. Therefore, to manage this stream it is necessary to know the word container size and the alignment (right or left).

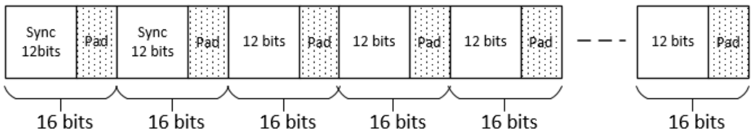

Figure 3

Figure 3 is an example of unpacked 12 bits PCM word on 16-bit word container

Packed mode is a synchronized minor frame put on a 16-bit or 32-bit payload size. So Additional bits are added at the end to complete the minor frame on a 16-bit or 32-bit full size frame.

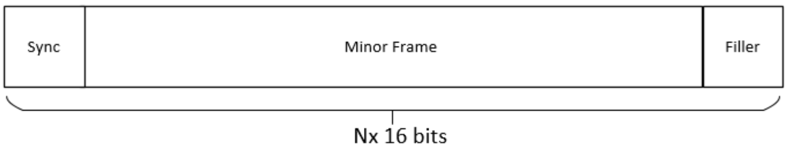

Figure 4

Throughput mode is used by telemetry receivers, which are not composed of a Frame Sync. So digital data are provided directly from the Bitsync Output and the stream is a raw data stream which could still be encrypted and not synchronized.

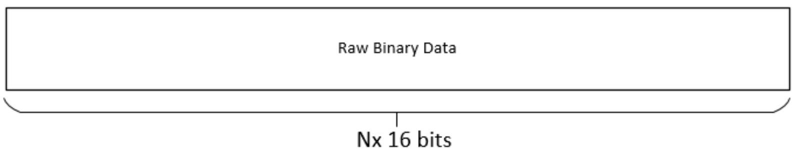

Figure 5

These three formats can be possible in the Ethernet output stream of a TM station and in order to compare the contents, it is first required to standardize the format before proceeding to BSS.

Ethernet BSS Architecture

With these well-known Ethernet PCM stream formats, it is now possible to define a BSS with an architecture able to manage these heterogeneous streams. Regarding the previous chapter an architecture based on three layers is adequate:

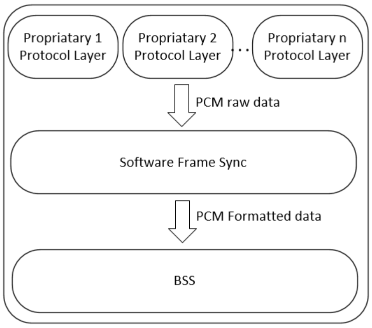

Figure 6

Proprietary Protocol layer is in charge of extracting the required information for the BSS from specific data format:

- Timestamp
- PCM stream
- Quality factor (if provided)

This layer will be specific depending on the source (manufacturer) of the Ethernet Telemetry. There will be as much Proprietary Protocol layer module as manufacturers.

Software Frame Sync layer will have three goals:

- Proceed to the frame sync on throughput data
- Reformat extracted data (unpacked or packed) for suitable comparison in BSS
- Extract Lock Quality Factor

Using the Soft Frame Sync will sort the data in a common format to make data easy to compare for BSS.

Parameters input of this frame sync are

- The PCM format (FS size, MF size, mf size, word size etc…)
- The Word mapping (Word container size: 16 or 32 bits, MSB or LSB…)
- PCM payload buffer
- Timestamp of the buffer

From these inputs, the soft frame sync will provide a timestamped standardized output.

The interest of the Software Frame Sync is that any kind of data format can be managed: Throughput data, PCM words from 3 bits to 32 bits, swapped or not, MSB or LSB…

Finally, the output is always in the same format: MSB PCM word on 16 or 32 bits word container.

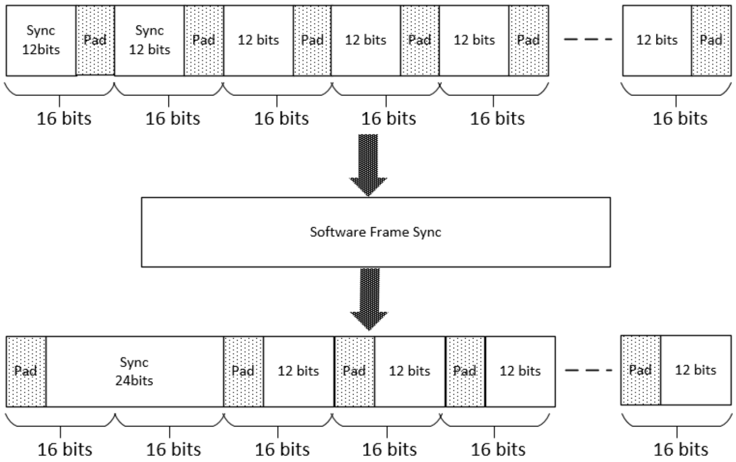

Figure 7

Figure 7 shows the reformatting of a 12 bits PCM word packed stream. The output holds the same data but in a different way that will be comparable with the other sources.

Once this part is complete, the BSS will always work on standardized data streams.

BSS can then be applied on all the sources received, as they are now comparable. Additional Quality factors extracted from the proprietary layer can help to the decision following the criteria and the weighting associated to these factors. Each minor frame is timestamped and with SFID information, it is possible to time align the different sources and proceed to BSS algorithm.

Figure 8 shows an example of a PCM stream comparison from three heterogeneous sources.

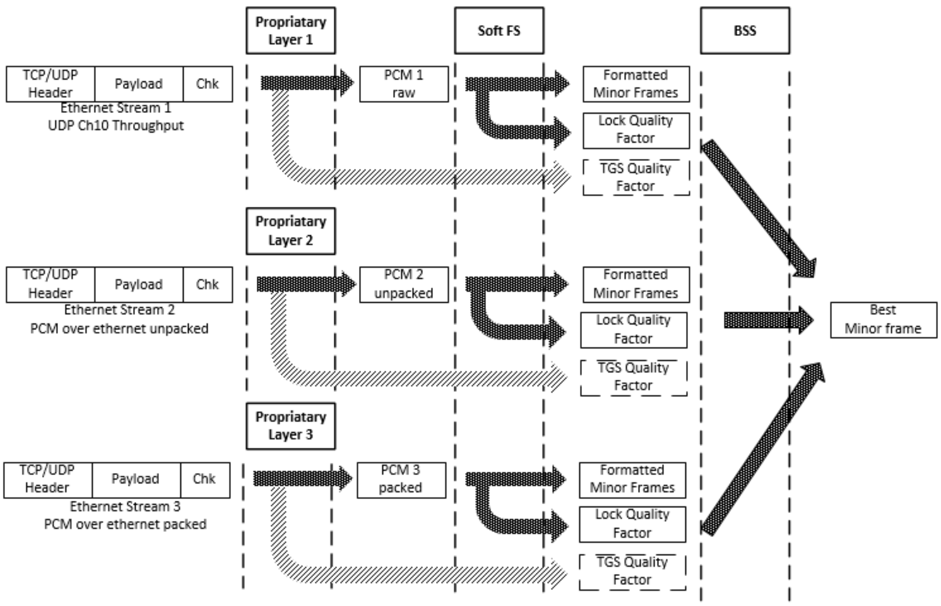

Figure 8

In this example, the three sources are carrying the same PCM stream but in heterogeneous format. Proprietary layer extracts the PCM stream information and the quality factors. Software Frame Sync formats the PCM streams in comparable data frames so it is possible to compare it in the BSS. All the minor frames are timestamped and can be compared bit to bit with the weighted quality factors.

Practical case

To validate this model, several architectures have been tested with good results.

The Three layers BSS have been implemented in MAGALI Telemetry Software used as the telemetry data software.

The first practical case is based on Telemetry receivers sending proprietary Ethernet Output in throughput mode which are connected to MAGALI decom station. Each Telemetry Receiver sends three Ethernet Outputs (LHCP / RHCP / Combined) at 30 Mbps to the MAGALI telemetry software.

The decom station had to produce a QLM (Quick Look Message) stream. This is an Ethernet message (50Hz) composed of selected Telemetry parameters (filtered from ICD).

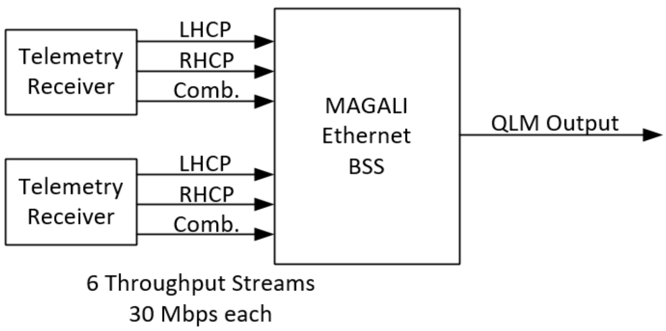

Figure 9

The Telemetry Stream is a 30Mbps PCM-FM with 50 µs minor frames.

The tests have been done on Core i7-6700@3.4GHz CPU. CPU Load was around 20% for the six streams with a 130 Mbps Ethernet Load. Delay measurement was around 60ms with a deviation of 30 ms.

The second practical case is based on three heterogeneous sources as shown in figure 10. The system had to generate the best Ch10 unpacked telemetry stream. The sources came from several installation on the range.

- A new receiver able to provide TM throughput signals in Ch10 format
- A MAGALI TGS front end which provides Frame synchronized data blocks
- A PCM source which has been upgraded few years ago with a PCM to Ethernet Module to broadcast telemetry over Ethernet. This source was a redundant source in case of failure as there is no other quality factor than Frame sync Lock.

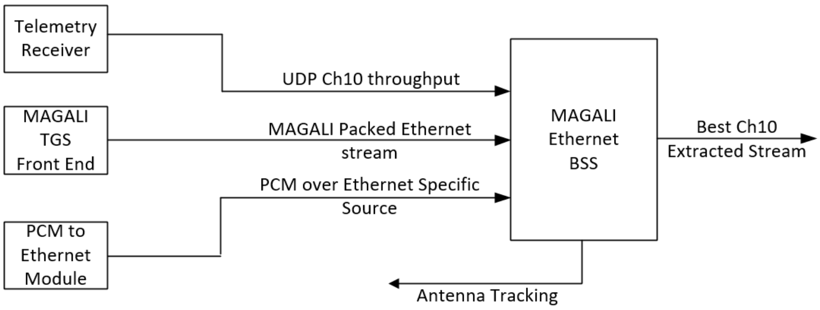

Figure 10

The bit rate in this case does not exceed 10Mbits but the interesting aspect is the heterogeneous sources as PCM inputs. Even if the complete installation has not been upgraded with the same hardware interfaces, the Ethernet BSS is able to manage the different kind of inputs. Therefore, end customer did not have to buy other hardware to manage the different inputs. Time delay has not been measured for this project, nevertheless the system was performant and delay was not exceeding 200ms to provide the Ch10 stream in real time.

Conclusion:

The Ethernet BSS architecture is a good answer to the prolific Ethernet PCM format that all the manufacturers can propose.

This solution is a low cost investment as it is only software based. Moreover, the three layers architecture provides a flexible model in case of new format management, only the first layer has to be upgraded with a new plugin in order to manage the new format. Software Frame Sync & BSS Layer remains the same once the information are provided.

The constraint of this architecture is in case of encrypted data, throughput data cannot be compared with synchronized data. It is necessary to decrypt all the data before using this method or to compare only encrypted throughput data based on a random sync pattern. Moreover, all the Ethernet packet needs to be timestamped as the Ethernet communication is not deterministic; the packets cannot be received synchronously from all the sources at the same time.

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