THE IMPACT OF NETWORKS ON THE RF LINK

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ABSTRACT

Using a network-based telemetry system places additional requirements on the Radio Frequency (RF) link. Limitations imposed by this link must be considered in advance when designing a network-based telemetry system.

KEY WORDS

Networks, Radio Frequency Link

INTRODUCTION

In the not too distant past computer processing was expensive. Data from sensors on a test vehicle was collected, formatted into an IRIG 106 telemetry frame, and transmitted to the ground. The data was then processed by expensive computing systems at the range and given to the end user.

With today's inexpensive processors, this method of collecting and distributing data is changing. Data can now be partially processed at several locations in the network and in some cases the sensors can process their own data. Transducers can read in both temperature and the desired parameter and then apply temperature compensation. Calibration curves can be loaded directly into the sensor so that the output provided is already in engineering units.

The data acquisition system can also participate in the process. Sensor data can be sampled at a high data rate, filtered with a digital filter, and re-sampled at a lower data rate. This partially processed data can then be placed into packets for transmission to the ground. On the ground, these packets can be split up and distributed to the end user.

Figure 1 provides comparison of a network-based telemetry system and a traditional telemetry system.

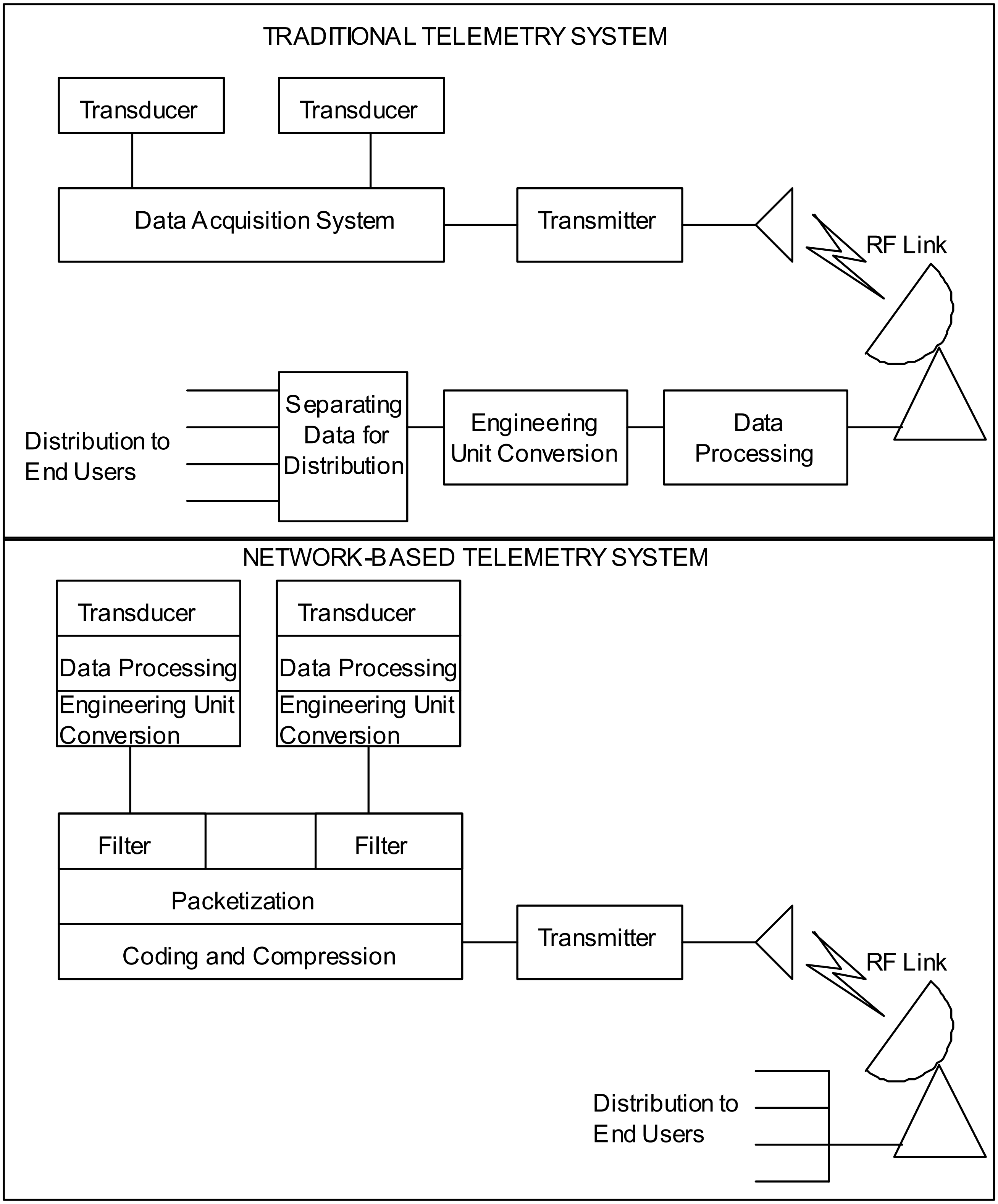

FIGURE 1.
COMPARISON OF TRADITIONAL AND NETWORK-BASED TELEMETRY SYSTEMS

ADVANTAGES OF THE NETWORK-BASED TELEMETRY SYSTEM

A network-based telemetry system provides greater flexibility. For example, during the boost phase of a multistage vehicle, the first-stage transducers are of primary interest. After staging, these sensors are no longer of interest, but the sensors from the upper stage are. A network-based telemetry system allows sensors to be added or deleted during the flight.

Placing data in packets aids in data compression. An IRIG 106 format frame has data collected from a variety of transducer types mixed in the frame. The result is a pseudo-random collection of bits that is not easily compressible. As an extreme example, consider a system consisting of video data examining a dark field and accelerometer data in a traditional Pulse Code Modulation (PCM) frame. The samples from the video data are interleaved with the accelerometer data resulting in a data stream that is not easily compressed. However, if the data is sent as packets, the video data can be greatly compressed resulting in a much lower data rate.

A network-based telemetry system also facilitates delivery of the telemetry data to the end user. The data can be sent over the network directly to the user rather than first sending the data to a centralized area for processing and then striping out the data to the end user.

EFFECTS OF THE NETWORK-BASED TELEMETRY SYSTEM ON THE RF LINK

The benefits of the network-centric telemetry system place additional constraints on the RF link. Networks are typically bi-directional while traditional telemetry systems send data in only one direction. A network-based telemetry system may require an uplink to change the parameters of the acquisition system. The user may wish to stop taking data from one sensor and begin taking data from another set of sensors. Or, prior to an expected event, the sample rate of a sensor may be increased, and the digital low-pass output filter cutoff may need to be increased.

The increase in data compression enabled by the network-based telemetry system imposes constraints on the RF link. Compressed data is generally far more sensitive to noise in the RF link. Depending on the type of compression used, a single or few bit errors may make an entire block of data unusable. A bi-directional data link helps overcome this limitation by requesting retransmission if a parity bit or checksum is not correctly received. Alternatively, forward error correction (convolutional code) concatenated with an outer code (such as a Reed-Solomon block code) can be used to reduce the bit error rates.

Data also can be interspersed in various blocks so that bursts of noise do not destroy any single block. A simple example would be transmitting each block twice (with a checksum or parity bits to determine which block was not corrupted by noise). Periodic convolutional interleaving also can serve this function.

Care must be taken to ensure that the gains from data compression are not overcome by the increase in overhead in forward error correction, retransmission, or redundancy to overcome noise bursts.

A network-based telemetry system has the advantage of delivering data directly to the user. In a traditional system, the processing agency can separate the invalid data and only send the noise-free data to the user. In a network-based system, the end user receives both valid data and data corrupted by noise. The result can be a user that draws incorrect conclusions based on noise that resembles data. If the user becomes accustomed to noisy data, critical data may be discounted and assumed to be noise. Finally, failures may occur if a user does not take appropriate action on real data that is presumed to be noise.

Noise presented to the user can be minimized by requiring the RF link to provide a lower bit error rate, or using a Reed-Solomon or other code which alerts the user when there are too many errors to correct.

DATA LATENCY

Data latency also must be considered when designing a network-based telemetry system. Range Safety may require a minimum latency for Range Safety critical parameters.

In the event of vehicle failure, the last few milliseconds of data are often critical to understanding the failure cause. If data is being stuffed into packets, or filling a buffer to be compressed and/or block-encoded, and the vehicle failure causes loss of telemetry, the failure cause may be difficult to determine.

Latency can be minimized for time-critical data. These parameters can be assigned a lower level of data quality and be placed in a virtual channel without error correction.

Eliminating block codes and/or data compression can reduce latency. Higher power transmitters or higher gain antennas on the vehicle or ground can compensate for the lost coding gain or higher bit rates without compression.

CONCLUSIONS

A network-based telemetry system places additional constraints on the RF link. Improved bit error rates may be required. Coding the signal or using higher power transmitters or higher gain antennas also may be necessary to obtain the lower bit error rates.

A network-based telemetry system can add latency. In the case of a vehicle failure that results in loss of the RF link, data latency may cause a loss of critical data. For this type of application a network-based telemetry system may not be appropriate.