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Measurement and Evaluation of Data Collection by the International Monitoring System

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The collection of data through the monitoring networks of the International Monitoring System consists of sequences of transformations from the sources, i.e., the respective sensing elements, to the archival database or sink at the International Data Center. Although there are differences in the details of the operation for each of the four networks, the underlying principles are similar, particularly for the hydroacoustic, infrasound and seismic ones that generate and transmit data continuously and in near-real time. Transducers generate analog signals upon excitation by physical phenomena. The signals are converted into data that are transported via data transport channels to the International Data Center where the sampled versions of the source analog signals are used to detect events. Ideally, the reconstructed signal samples should be identical to the sampled versions of the analog signals at the source and the reconstructed analog signals should be facsimiles of those generated by the sensing elements. In practice, each transformation introduces errors so that the reconstructed signals differ from those generated by the transducers. Quantifying and measuring those differences would allow the establishment of criteria for measuring the performance of individual source-to-sink data paths as well as each monitoring network and, ultimately, the entire International Monitoring System.

The challenge is to define each transformation so that it can be modeled quantitatively in order to analyze its impact on the data stream. One can start from the ideal case of creating a facsimile of the source signal. The sampling theorem forms the theoretical basis for the sampling and reconstruction operation. The first category of errors in the reconstructed signal pertains to the performance of the anti-aliasing filters, the digitizers and the analog-to-digital converters. Their performance can be specified in terms of bandwidth, selectivity, sampling rate and dynamic range.

The serial data stream generated by the sampling and quantization of the output of each sensing element is converted into data blocks or frames. In reconstructing the source signal, the reverse operation takes place that generates a serial stream of samples from which the signal is re-constructed. These transformations are also well-defined, can be modeled and their performance measured in terms of the errors they can introduce on the samples and the frames.

The third major transformation of the data stream is done by the transport mechanism that links the remote site with the International Data Center. Within that link, the frame stream is converted into electrical signals and back into a frame stream through a sequence of transformations that also well-defined, can be modeled and their performance measured in terms of the errors they introduce on the frame stream. This paper describes how this sequence of transformations can be combined to generate a model for measuring and evaluating the end-to-end performance of the monitoring system by analyzing the impact of each transformation on the quality of the data as they are being transformed.