

Use of IEEE 2664 for Transmitting Point on Wave Records

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Abstract— With the increase in substation devices capable of recording point on wave records and the increasing availability of network connectivity in the field, utilities have shifted to retrieving data remotely via network connections. A variety of protocols and standards have been developed to address streaming continuous data, however, most do not address the issue of retrieving triggered records, such as those created by Digital Fault Recorders (DFRs), Relays and Power Quality Meters (PQMs).

This paper introduces a variation of the IEEE 2664 Protocol applied to transfer triggered point on wave (POW) records. A case study, including deploying this protocol on a Digital Fault Recorder, and transferring this data is discussed and significant reduction in latency and bandwidth requirements are shown over more common protocols such as PQDif over FTP.

Keywords—Point On Wave; Communication; DFR

I. INTRODUCTION

With the recent introduction of new power quality meters (PQMs) and more advanced digital fault recorders (DFRs) there is an opportunity to use the measurements obtained from these devices for various engineering and operational processes. This has driven an increased interest in retrieving the data remotely via network connections. A variety of standard protocols can be used for storing and transferring the data, such as FTP, SFTP, PQDif and COMTRADE. However, none of these protocols take advantage of the unique structure of point on Wave records and address issues associated with transferring the data across limited bandwidth networks, such as those going out to remote substations. This paper introduces the a compression algorithm, specifically designed to allow use of IEEE 2664 to transfer point on wave data. Section II describes IEEE 2664 and the challenges associated with using it on point on wave data in more detail. Section III describes the compression algorithm developed to use on point on wave data. Finally, Section IV contains some experimental results obtained from applying the proposed algorithm on real world triggered point on wave data. lessons learned at the Tennessee Valley Authority.

II. IEEE 2664 OVERVIEW

IEEE 2664 (STTP) is a data measurement centric, publish/subscribe transport protocol that can be used to securely

exchange time-series style data and synchronize metadata among applications. The protocol supports sending synchronized real-time and historical data at full resolutions

The wire protocol defined by STTP is targeted for packet-based transport protocols, specifically Internet Protocol (IP). STTP implements a publish/subscribe data exchange model using simple commands with a compressed binary serialization of data points. The protocol does not require a predefined or fixed configuration - that is, the identifiable data point values arriving in one data packet can be different than those arriving in another. Each packet of measurement data consists of a collection of data values where each value is defined by a compact structure containing an identifier; a timestamp or sequence index; a value; and any associated data quality flags.

STTP was original developed for sending synchrophasor data [1]. Previous work has also applied STTP to sending 2-channel audio data. Both, audio-data and synchrophasor data share similar characteristics [2], resulting in high compression ratios when using Time Series Special Compression (TSSC). While STTP is was designed with TSSC as the standard compression protocol, it supports use of custom compression algorithms tailored to the data. [1]

III. COMPRESSION OF POINT ON WAVE DATA

Unlike Slow changing synchrophasor data, Point on wave data changes significantly over a single cycle. Using standard TSSC results in a low compression factor and significant overhead.

Most measurement devices recording triggered point on Wave data support COMTRADE or PQDif formats. While these file formats do not offer any significant compression options, the files can be compressed for transfer using standard GZIP compression, resulting in reduction in file size.

Fig. 1 shows a comparison of size of a 15 minute Point on Wave record encoded as binary raw data, PQDif and PQDif with standard GZIP compression.

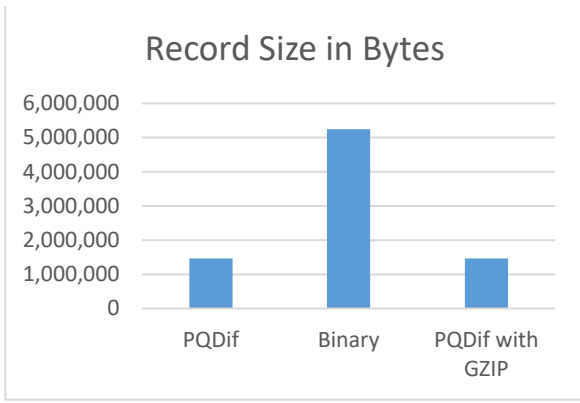


Fig. 1. point on wave record size in various data formats

This paper proposes an alternative approach to compressing Point on Wave data to be used in combination with STTP to significantly reduce bandwidth requirements for transferring a point on Wave records over using FTP, GZIP and PQDif.

Under most operating conditions point on wave data can be described as

$$x(t) = A * \sin(\omega t + \theta) + \epsilon(t)$$

Where A is the Amplitude, ω, θ the frequency and phase offset, and $\epsilon(t)$ some residual. The residual has a significantly smaller rate of change. The characteristics of $\epsilon(t)$ allow the use of TSCC at a significantly better compression rate than $x(t)$. By encoding the waveform parameter A , ω and θ additional overhead in the data, some overhead is added. As long as the additional overhead is smaller than the reduction in size gained by using TSCC on $\epsilon(t)$ there is a net benefit to using this approach.

A similar approach can be used to further improve the compression effects of TSCC on $\epsilon(t)$ as

$$\epsilon(t) = A_1 * \sin(\omega_1 t + \theta_1) + \epsilon_1(t)$$

Chaining this approach results in

$$x(t) = \sum A_i * \sin(\omega_i t + \theta_i) + \epsilon(t)$$

Where a set of parameters A_i, ω_i, θ_i in addition to $\epsilon(t)$ are encoded to represent the entire point on wave record.

Assuming all parameters are 64 bit floating integers, the total size of the compressed record is given by

$$N_{Total} = 3 * (64) * n + N_{TSCC}$$

Where n is the number of sinuoidal waves used and N_{TSCC} is the size of the residual ϵ after TSCC is applied.

Fig 2 shows N_{TSCC} as n is increased from 1 to 10 for a 2 cycle sample. Once n becomes large and ϵ in term get's smaller) the gain in compression ration becomes increasingly small. As a result an appropriate size of n has to be chosen for optimal compression.

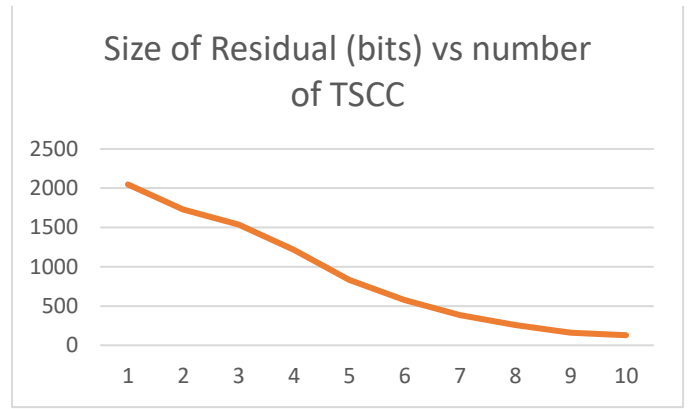


Fig. 2. Size of the residual as number of TSCC applications is increased

IV. REAL DATA RESULTS

The algorithm described in the previous section was implemented and tested on several real world point on wave records. Fig 3 shows some of the original data used.

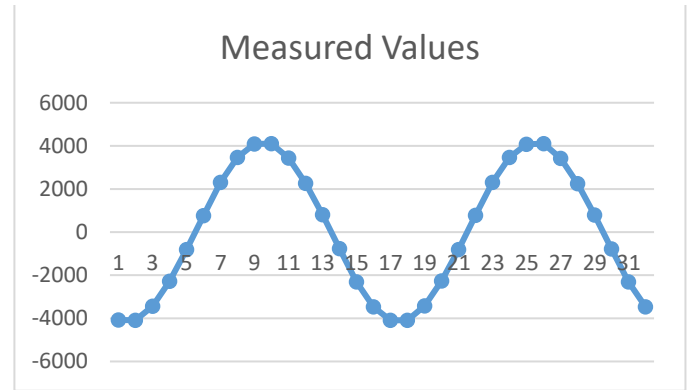


Fig. 3. Section of the original point on wave record

Fig 4 shows the residuals $\epsilon(t)$ for $n=1$. Since most of these records are well conditioned and taken under normal operating conditions the residual is already fairly small for $n=1$.

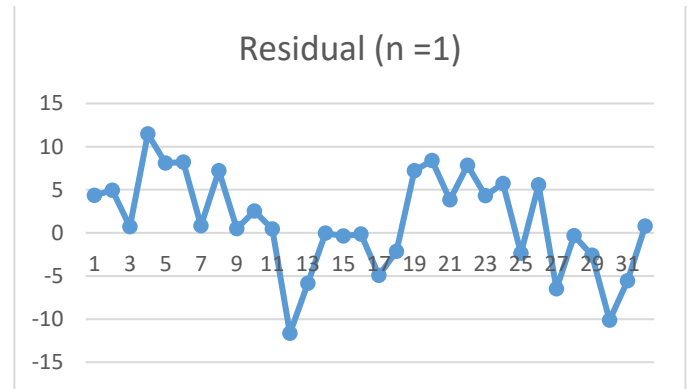


Fig. 4. Residual after applying 1 TSCC iteration ($n = 1$)

Fig 5 shows the size of the data after the optimal n in range 1 to 10 is applied. Note that the optimal n was determined based on trial and error for each dataset.

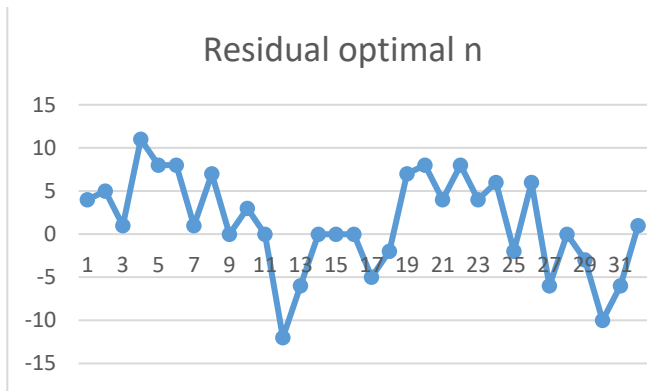


Fig. 5. Residual after applying optimal number of TSCC iterations

Fig 6 shows the distribution of the optimal n for the datasets used in this study. Based on these results it is possible to estimate an n of 8 as a general approach. While this may not result in optimal compression in all cases, it does result in an average compression ratio of almost 27%.

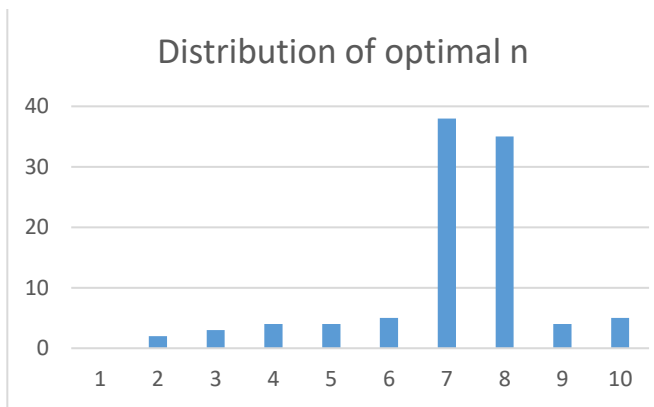


Fig. 6. Distribution of optimal number of TSCC iterations

V. CONCLUSION

This paper introduced a compression algorithm to be used with Point on Wave Data for using IEEE 2664 for transferring triggered point on wave records. Initial tests, using real world triggered point on wave records show a size reduction of 5% over using standard GZIP of the PQDif records. Further Research will be necessary, to determine improvements on the algorithm under abnormal system conditions, such as faults and interruptions.

REFERENCES

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