On the Patterns of the Nonstationary Datagram Based Fast Communication Processes[*]

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Abstract

Expectations against modern communication services today involve not just Quality of Service (QoS) enhancement for real-time applications but also increased transmission rate between the storing and processing of Big Data nodes. Transmission Control Protocol (TCP) has strict flow control of the data stream providing automatic adaptation to the path load of the process-to-process communication. User Datagram Protocol (UDP) based solutions are proposed to settle the communication efficiency. In this paper, we analyse the effect of three independent communication parameters on the efficiency of UDP communication: the size of the Maximum Transfer Unit (MTU), the bandwidth of the end-to-end session and the segment size of the UDP protocol data unit. The usage of non-stationary multiresolution methods helps to extract characteristic patterns offering identification of the objective qualitative features of the data communication services.

1. Introduction

Forcible flow control of the TCP provides process-to-process service with low-efficiency usage of the communication paths resources like links, buffers and processors of the intermediary nodes [4]. The lack of justification for this strict connection-

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oriented mechanism implies technological reconsideration in practice and opens development steps toward the usage of simpler and faster UDP extended with reliable services [3]. Classical time series analysis (TSA) statistical methods to evaluate properties of data communication services consider stationary features of the data series. Time series captured from fast communication sessions prove the non-stationarity of the real data transfers. New evaluation methods are required for these processes.

2. Applied Methodology

A UDP-based communication session was used to upload several hundred times a fixed-size data file to a test server with different combinations of the independent parameter triplets (MTU, Bw, SSize). Because the processes are not stationary we used Empirical Mode Decomposition (EMD) [7], Variational Mode Decomposition (VMD) [2], Empirical Wavelet Transform (EWT) [5] and Short Time Fourier Transform (STFT) [6] methods to decompose the interarrival time (IAT) data series $x(t)$ into a sum of approximately orthogonal modes and residual $res(t)$:

$$x(t) = \sum_{i=1}^{k} mode_i(t) + res(t) \tag{1}$$

These modes belong to frequency bands being disjunct or nearly disjunct depending on the decomposition method applied [8][1]. The main properties of the applied decomposition methods are given in Table 1.

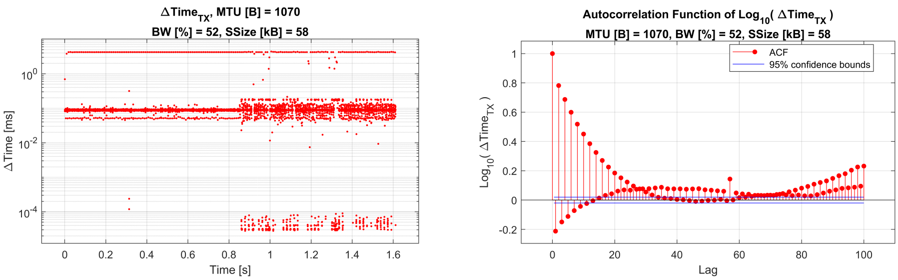
Table 1. Main properties of the decomposition methods.

Property	FFT	STFT	DWT	EMD	VMD
Time domain	No	Yes	Yes	Yes	Yes
Frequency domain	Yes	Yes	Yes	Yes	Yes
Filtering aspect	Global	Linear	Diadic	Diadic	Linear

To characterize IAT processes in time-frequency domains we used the Hilbert transform of the modes. To extract the DC component it was applied property of the Hilbert transform to shift the phase by $\pi/2$ of the original signal. The remaining AC components serve to determine the spectrum of the signals and extract patterns.

3. Summary of the Results

IAT time series of the fast communication services (see Figure 1a) have non-stationary characters (see Figure 1b). Decomposed modes of the IAT serve to determine characteristic time patterns in multi-resolution frequency scales. It was found that the UDP mechanism generates specific patterns in the time and frequency domain which characterize clusters of independent parameter triplets.



(a) **(b)**

Figure 1. a) Interarrival time series $x(t)$ of the file transfer in case of parameter triplet (MTU, BW, SSize) = (1070 B, 52 %, 58 kB); b) Autocorrelation function of $x(t)$.

A comparison of the decomposition duration was executed to help researchers in the decision of the analysis method selection to extract essential features of the packet switching based fast communication services.

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