Analyzing the Ways of Matching Dynamic Features of Video Stream to Information and Communication Networks

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***Abstract* — The work deals with the current problem of delivering video data with controlled loss of quality in information networks. Means of controlling the bit rate of video streams are studied. The development of structural and functional chart for controlling minimum bit rate of video stream data with controlled loss of quality is grounded.**

***Index Terms* — video stream, video information, bit rate, bandwidth, bit rate control.**

I. INTRODUCTION

Problem analysis and current state of research. The current state of information networks is characterized by high rates of increasing information circulating in them, rising the number of transmitted data. However, the rate of consumer segment development far exceeds functional capabilities of equipment, which makes it impossible to provide all applications with the desired throughput.

Solving the problem of timely video delivery with controlled loss of quality in the information network comprises some aspect levels.

The first aspect level focuses the fact that matching video stream intensity variable and network features that are dynamically changing is relevant for practice. It is necessary to prove the following:

On the one hand structural, statistical, psycho-visual and semantic features of video stream are changeable, which result in changing the intensity of compressed video stream values.

On the other hand the network features are also changeable due to network discontinuity, uneven load on the network switches which are dynamically changing with the change of the number of the network users number and their service needs.

The second aspect focuses the fact that the current technologies of traffic intensity control operate on the transport and network levels. They do not affect the total intensity of video stream and do not take into account their features, which leads to the dissatisfaction of the quality features of the end-user considering the video quality perception by the end user. Therefore it is necessary to develop technologies of video intensity control on the level of source of information (the level of network representation).

The third aspect focuses the fact that existing compression technology does not enable developing matching technologies which meet the requirements of video information servicing with the use of information and communication technologies.

Problem statement. The aim of this article is to develop a bit rate control method to ensure matching the video stream features which are dynamically changing and information and communication network features.

II. MAIN PART

Network traffic of modern computer networks has random and non-stationary character due to the changes of data streams intensity at different time of the day and unpredictable nature of network subscribers' work. The intensity of compressed video data stream, their structure and amount depend on the content of output images as well as on peculiarities of their processing technology.

In general, the video stream which comes into the encoder has uniform speed which depends primarily on the spatial extension of a frame, frame rate and the depth of brightness, i.e. on the number of bits needed for each image pixel

$$V(t) = f_k \cdot MN \cdot d \text{ (bit/s)} \qquad (1)$$

where f_k is frame rate; MN is spatial expansion of traffic; d is depth of brightness.

However, assessing the source bit rate it is necessary to take into account traffic discontinuity and complexity considering the types of video applications, their requirements to visual quality, communication bandwidth, time delays while processing and different strategies for classified frames processing. This leads to a ripple in video stream bit rate.

Traffic generated by network subscribers that use video transmission (separate image files, video on demand or streaming video of varying quality) has a distinct induction and pulsating character.

It should also be noted that data video stream has a variable rate, which is affected by a number of users and a type of applications with different requirements to communication channel features and parameters of compression algorithms.

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Video stream is processed in the encoder before entering the communication channel (Fig. 1), then the data speed changes in the time range (Fig. 2).

This occurs due to changes in the features of processed images that can be represented as:

– statistical features (the measure of correlation of image segment elements, temporal and spatial redundancy);

– structural features (brightness, color saturation, the degree of fine details saturation, the complexity of circuits).

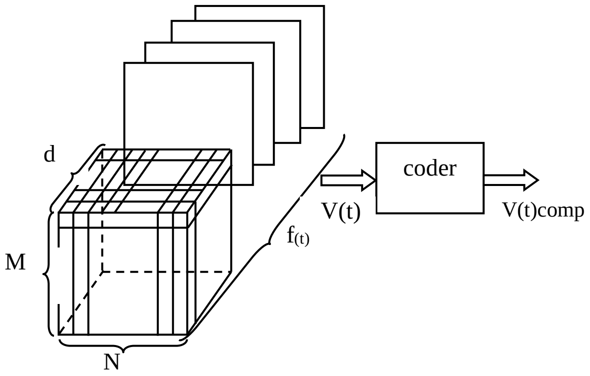

Fig. 1. The structure of video stream

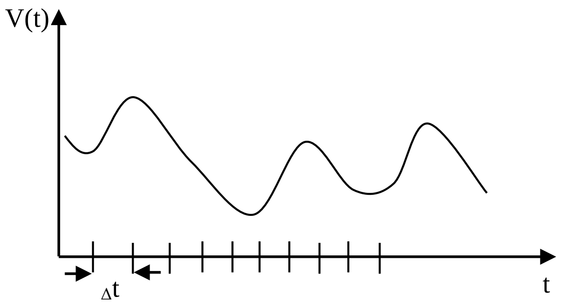

Fig.2. Bit rate variation

Thus, the video stream bit rate is defined as the function several variables:

$$V_{comp} = F_{comp}(f_1, f_2, f_3, f_4, f_5, f_6, f_7) \quad (2)$$

where f_1 is statistical features of the output image; f_2 is structural features of the output image; f_3 is image segment size; f_4 is color model type; f_5 is image segmentation view; f_6 is quantization parameter; f_7 is coding type.

On the other hand the data rate is changing due to the fact that the mechanism of encoder action is the functional of dependence on statistical, structural psycho-visual features of an original image as well as the function of quality loss which in its turn depends on the quantization parameter. The coder speed which depends on the number of operations included into the algorithm of the coder operation should be also considered:

$$V_{comp}(t) = F_c\{Z_{st};\ Z_{str};\ Z_{psyh};\ f_{PK};\ P_{KK};\ T_{OBR}\} \quad (3)$$

where Zst is the parameter of image statistical features; Zstr is the parameter of image structural features; Zpsyh is the parameter of image psycho-visual features; fPK is the function of the loss of quality of the original image after processing; PKK is quantization parameter; TOBR is the time of encoder operation required for image processing.

Thus, there appear some difficulties in balancing the rate of bit sequence forwarding after the encoder to the communication channel.

The transmission speed, interference-resistant environment, computing performance affect the dynamics of network variables.

In other words, the total number of users creates a video stream that is constantly changing.

Also, the characteristics of the network are also changeable because of the networks discontinuity, uneven load on the network switches which are dynamically changed by the number of network users and their service requirements.

The transmission of video streams in the communication channels faces a negative factor regarding timely delivery of video data streams to the recipient via the so-called "ripple" directly in communication channels.

There are two types of communication channels; they are a so-called channel with switching and the network based on packet switching. The channel with switching (the channel with constant speed) is not adapted to transfer video streams with varying speed,.

At the same time, networks based on packet switching support varying speed of transmission. However, these networks have a negative factor of non-constant bandwidth. The channels bandwidth in its turn depends on the speed of communication as well as on overload. Thus, there is the question of control or adaptation of video streams bit rate for a particular channel. This concept of bit rate refer to the volume of compressed data and is produced by coder. Naturally, varying speed of video data streams can be smoothed with the buffer (Fig. 3).

Thus, the bit rate is the function of the compressed data volume per time unit and the time needed for data processing. Then, the bit rate control does not only consist of the unit of data volume but also of the time data processing.

The bit rate of a video stream is the function of several parameters:

$$R_t(t) = F_t(P_1, P_2, \ldots, P_n) + F(P_F, P_V, P_M), \quad (4)$$

where P_1, P_2, ..., P_n are variables of video stream parameters that include statistical features of the original image; structural features of the original image; the image segment size; the type of image color model; the type of image segmentation; quantization parameter and the type of encoding; P_A, P_V, P_M are network variables.

Among the above mentioned video stream variables it is possible to sort out the variables which can be controlled:

- the size of the image segment;
- the type of color model;
- the type of image segmentation;
- quantization parameter;
- statistical, structural and psycho-visual features both of the original image and the stream of video frames.

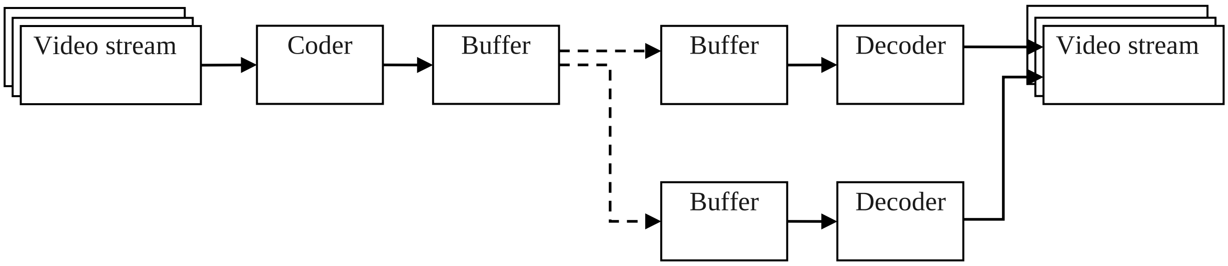

Fig. 3. Smoothing varying speed of video data streams with the buffer

Controlling these parameters leads to varying intensity values of the compressed video stream intensity.

The second part is the expression (4) is variables function of network characteristics. This occurs due to the network discontinuity, uneven load on network switches and dynamic changes in the number of network users and their service needs.

Thus, there is a contradiction that lies in the necessity of matching the video stream bit rate with the data transmission rate in the network. It is grounded by the fact that the video stream bit rate and data transmission rate in the network are constantly changing. Thus, there is the task to match the bit rate of a video stream according to the data transmission rate in the network Rt → Sk.

The process of matching the bit rate of a video stream (video stream intensity) to the data transmission rate in the network is referred to as matching process:

$$R_t = F_t(f_1, f_2, f_3, f_4, f_5, f_6, f_7) \rightarrow V_k \quad (5)$$

In order to match the video stream bit rate to the data transmission rate the following technologies are used:

- control of video stream bit rate realized in the form of special circuits built-in video codecs;
- means for buffering on the channel level and the level of encoders and decoders;
- implementation of general system control, such as routing or distributing channel and buffer resources.

The block diagram reflecting the essence of video stream bit rate matching to the data transmission rate in the network is shown in Fig. 4.

Control on the buffer level without taking into account the volume of video data has several disadvantages and does not solve the problem of matching bit rate to data transmission rate in the network. Buffering reduces the bit rate ripple only partially, since on the one hand, the greater memory the buffer device has, the higher ripple of the video stream bit rate can be smoothed out. But the greater the amount of buffer device memory, the greater the time delay, which results in reducing the speed of video data processing. The concept of control shifts on the priority level resulting in the loss of data with low priority

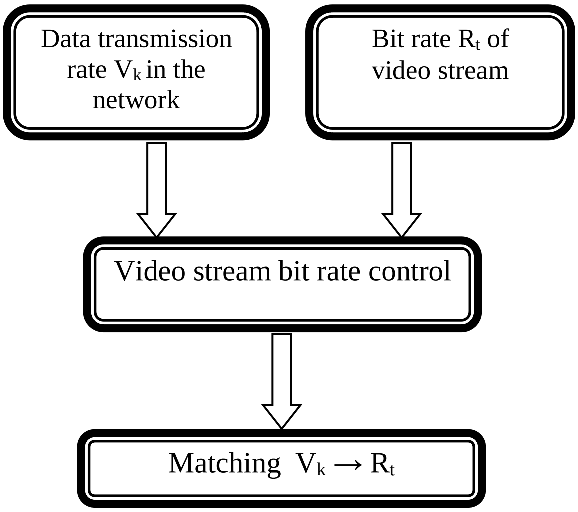

Fig. 4. The block diagram of matching video stream bit rate to data transmission rate in the network

. Existing technologies-of general system control while matching the video stream bit rate to the data transmission rate in the network do not reduce the intensity of the video stream, but just redistribute video traffic, which is their major shortcoming. If video traffic redistribution is not possible, the loss of video data occurs.

Therefore, it is necessary to develop the technology of video stream intensity control on the level of information source to reduce data loss while matching video stream bit rate to the data transmission rate in the network.

Structural and functional diagram that illustrates the essence of matching the video stream bit rate to the data transmission rate in the network is shown in Fig. 5.

The suggested diagram enables monitoring the communication channel bandwidth and assessing the network variables. Moreover, estimating the buffer workload, it is possible to affect the video stream variables.

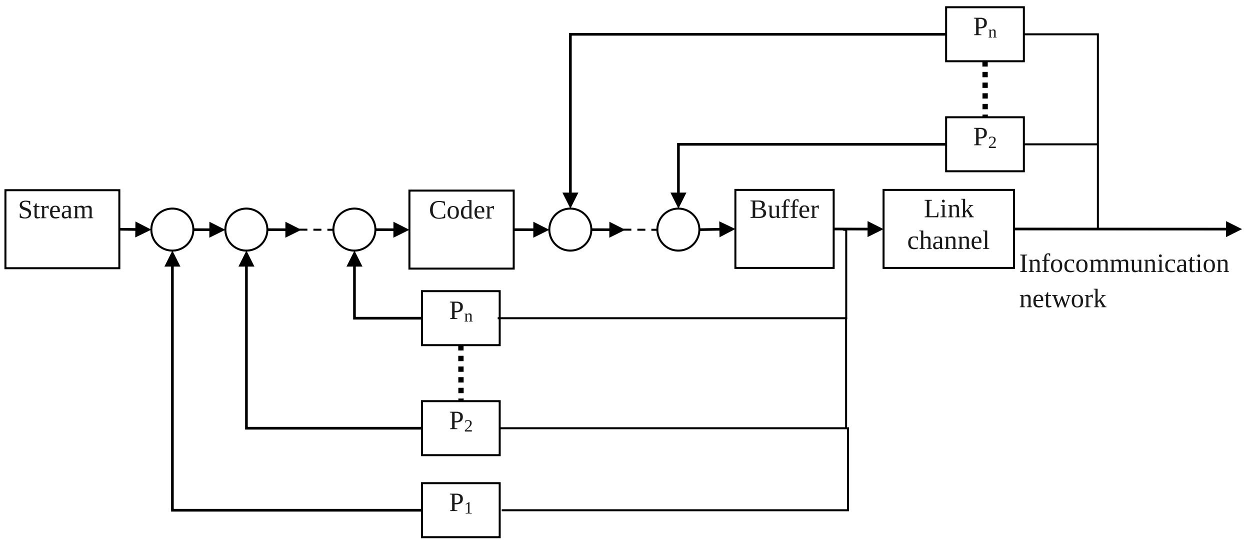

Fig. 5. Structural and functional diagram of matching video bit rate to the data network rate

Thus, to achieve the purpose of controlling the minimum video stream bit rate with the set quality loss, there is a mechanism of controlling packages parameters which anticipates the fact that the network is load so that the encoded streams enter the information and communication network.

III. Conclusion

1. The analysis of the video stream features and information network showed that there is a necessity to match the video stream bit rate to the data transmission rate in the network, which is caused by constant change of video stream bit rate and transmission rate.

2. Existing methods of smoothing the bit rate "jumps", using a buffer have some disadvantages.

3. It is reasonable to develop the structural and functional circuit which enables achieving the purpose of controlling the minimum video stream bit rate with a set loss of quality.

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