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Analysis of the Prospects for Developing Storage and Processing Complexes for Multiformat Media Data

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Abstract: A distinctive feature of multifunctional systems for supporting multimedia services on a single platform is the heterogeneity of incoming streams and requests, which requires optimization of resource use under physical constraints. In this regard, it is relevant to develop promising proposals for the functional structure and technical characteristics of complexes for storing and processing multi-format media data, which was the purpose of this study. Based on the laws of Moore, Amdahl, and Gustavson-Barsis, it is shown that the increase in the performance of such systems should be achieved not only by increasing the computing power and parallelization but also by optimizing the software used choosing its architecture, adequate technical requirements and optimizing the algorithms used. A list of promising proposals on the functional structure and technical characteristics of complexes for working with heterogeneous data is proposed, and their main modules and characteristics are considered.

Keywords: Multiformat Media Data, Content Delivery Network, Video Segment Analysis, Technical Requirements, Functional Structure

Introduction

In the constantly transforming modern digital world, saturated with multiformat data flows, problems of optimizing human-machine interaction, i.e., the interaction between users and computers at the level of the user interface, which includes software and hardware and adapting developed software and hardware solutions to the increasing level of user and digital service provider demands occur (Skripcak *et al*., 2013). Modern information systems, in addition to data processing, usually support several services and applications that provide access to end users.

To organize the operation of services in a single information space, it is necessary to solve several classes of problems, including optimizing the use of the available computing resources, depending on their demand in the conditions of physical constraints (Kommadath *et al*., 2022). Additionally, a distinctive feature of such systems is the heterogeneity of incoming flows of user requests due to the multifunctionality of modern information systems, expressed in supporting various multimedia services on a single platform (Xin *et al*., 2022; Falkowski-Gilski and Uhl, 2020). Each of these services has its requirements for the performance of computing resources, affecting the entire information system. To provide continuous access to information systems using modern means of telecommunications and communication, it is necessary to solve the problem of efficiently distributing a limited volume of resources between services. Here, the flows of incoming requests have a heterogeneous intensity and differentiated use of the main components.

It is also important to note that monitoring systems increasingly face the need to correlate heterogeneous multiformat data to obtain the resulting service state. Today, a universal solution capable of simultaneous load balancing and distribution among different multimedia services under physical constraints on computing resources does not exist. Versatile multifunctional software platforms for handling multiformat media data are under development and improvement to overcome difficulties in information anthropotechnical interaction.

The simultaneous control of an unlimited number of video, audio, and other signals in real-time on one or several computers monitors in multiscreen mode determines the prospects for developing digital telecommunication complexes. The main technical advantages are the successful combination of universal capabilities, multichannel, multiformat, and high reliability, which will ensure the further practical implementation of such systems in the projects of the largest information operators. The unique differences and advantages over traditional multiviewers include not only

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the reception and display of video and audio signals but also a complete instrumental analysis and monitoring of the parameters of each input signal.

The goals of creating digital telecommunication complexes for storing, processing, and forming a dynamic stream of multiformat data using Artificial Intelligence (AI) technologies are to create a multi-user complex unifying the work with data, automating processes, and facilitating description, data search using neural networks, which allows for improved data monetization through integration with external systems of line broadcasting and broadcasting on demand (Balmer *et al*., 2020).

The efficiency of using such complexes is to provide automated round-the-clock control over the dissemination of information in broadcasting networks with the ability to organize the control of different types of networks and to automate processes related to control and supervisory activities and information monitoring in terms of compliance with legislation in communications. The main objectives are:

- Ensuring continuous round-the-clock monitoring of broadcasting in analog and digital standards and automated identification of specified information and emergencies
- Ensuring control and supervisory activities as part of the data analysis process
- Obtaining, collecting, and structuring storage of information to provide the data monitoring process
- Providing analytical information on the data flow state, grouped by place, time, and source

Artificial neural networks, the most efficient modern tool for intelligent data analysis, are justified enough to solve the above tasks (Lv *et al*., 2022; Shanthi *et al*., 2022; Kim *et al*., 2014). The hardware, software, and algorithmic solutions are constantly being updated and the technical requirements are increasing.

In this regard, the current work develops promising proposals for the functional structure and technical characteristics of complexes for storing and processing multi-format media data. The study subject is the functional structure and technical characteristics of complexes for storing and processing multiformat media data and the object is these complexes themselves.

The analysis carried out in this study was based on the following hypotheses:

- Promising complexes for storing and processing multiformat media data should simultaneously distribute and balance the load between various multimedia services under the conditions of physical limitations on computing resources
- The advantage of digital telecommunication complexes compared with traditional multiviewers for receiving and displaying video and audio signals is the possibility of complete instrumental analysis and monitoring of the parameters of each input signal

Simultaneously, note that at present, there are no officially declared complexes for storing and processing multi-format data using artificial intelligence technologies in the Russian market, which emphasizes the relevance of work in this direction.

A problem of modern high-loaded information systems is the need for large amounts of computing resources. Here, the growth of resource consumption, in contrast to the change in the available computing resources, has an exponential nature, according to Moore's law (Shalf, 2020). Moore's law is an empirical observation, initially made by Gordon Moore, according to which (in the modern formulation) the number of transistors placed on an integrated circuit chip doubles every 24 months (Thomasian, 2022). The often-quoted interval of 18 months is related to the prediction of David House from Intel. According to him, processor performance, i.e., a quantitative characteristic of the speed of performing certain operations on a computer, should double every 18 months due to a combination of growth in the number of transistors and an increase in processor clock speeds (Kosky *et al*., 2013).

Figure 1 shows the growth in the number of transistors on a microprocessor chip. The vertical axis has a logarithmic scale, i.e., the straight line corresponds to the exponential law-the number of transistors approximately doubles every two years.

To improve the system's performance, it is necessary to use parallel computing (Maksum *et al*., 2022; Camacho-Vallejo and Garcia-Reyes, 2019). However, not every algorithm lends itself to paralleling, thus defining the fundamental efficiency limit of solving a computational problem according to Amdahl's (Nutaro and Zeigler, 2017) and Gustavson-Barsis's (Barlas and Keat, 2022) laws. Let us briefly consider each of these laws.

Amdahl's law illustrates the growth limitation of computing system performance as the number of computators increases. Gene Amdahl described this law in 1967 after discovering a simple but insurmountable limitation on performance growth when paralleling computations: "When a task is divided into several parts, its total execution time on a parallel system cannot be less than the execution time of the slowest fragment." Figure 2 shows the operation of the law-the size of the sequential part of the program limits the program speedup with parallel computing using several processors. For example, if it is possible to parallelize 95% of the program, theoretically, the maximum speedup will be 20 times, no matter how many processors are in use.

According to Amdahl's law, the time needed to execute its sequential instructions limits the speedup of program execution due to paralleling its instructions on a set of calculators. The speedup can be calculated using Eq. 1:

$$S_p = \frac{p}{\alpha p - \alpha + 1}, \tag{1}$$

where, a-the share of the total number of calculations possible to obtain only by consecutive calculations; (1-a) - the share of the total number of calculations possible to parallelize perfectly; *p*-the number of nodes.

Amdahl's law shows that the gain in computational efficiency depends on the problem algorithm and has a limit from above for any problem with $\alpha \neq 0$. This follows from Amdahl's law that not for any problem reasonable to increase the number of processors in the computational system. Moreover, considering the time required to transfer data between computational system nodes, the dependence of computation time on the number of nodes will be minimum. This restricts the scalability of the computational system, i.e., it means that from a particular moment, adding new nodes to the system will increase the time of the task calculation.

Further, let us consider Gustavson-Barsis's law. This law allows for the estimation of the maximum achievable speedup of a parallel program, depending on the number of simultaneously executed computation flows ("processors") and the proportion of consecutive computations. Equation 2 expresses Gustavson-Barsis's law:

$$S_n = s + (1-s) \cdot n = n + (1-n) \cdot s, \tag{2}$$

where, *s*-the share of consecutive calculations in the program; *n*-the number of processors.

This speedup estimate is the so-called scaled speedup since it shows how efficient parallel computing can be when the complexity of tasks increases.

In estimating the speedup of parallel execution, Amdahl's law assumes that the task volume remains constant (Yavits *et al*., 2014). The speedup value, according to Amdahl's law, shows how many times less time the parallel program will take to execute. However, the speedup value also means an increase in the scope of the task over a constant time. Gustavson-Barsis's law emerged precisely from this assumption.

Thus, performance improvement should result not only from increasing computing power and paralleling but also from optimizing the used software: Choosing its architecture, adequate technical requirements, and optimization of used algorithms. The four well-known laws of software presented by Nathan Myhrvold in a lecture in 1997 support this thesis:

- Software is like a gas; it expands to fill the entire vessel
- Software grows until it reaches the limits set by Moore's law
- Software growth makes Moore's law possible-people buy new hardware because the software requires it
- Only human ambitions and expectations limit software

The analysis of this information concludes that the problem of limited resources is particularly relevant. Moreover, to ensure continuous access to information systems using modern telecommunication and communication means, it is necessary to solve the problem of efficient distribution of limited resources between services. Here, the flows of incoming requests have heterogeneous intensity and differentiated use of the main components (Kotenko *et al*., 2019), particularly the development of integrated telecommunications systems, the transition to higher-speed information flows, new methods of modulation and coding (El Jbari and Moussaoui, 2022) and video playback and storage (Ohnishi *et al*., 2019). Thus, many problems arise whose successful solutions require new, non-traditional methods of information processing, which would consider the properties, laws, and dynamics of telecommunication environments of data transmission, intellectualization of the technical devices themselves, and their high degree of adaptation to the actual interference situation on the communication channel (Quasim *et al*., 2022).

Nevertheless, universal solutions capable of simultaneously distributing and balancing the load between different multimedia services under physical constraints on computing resources are absent. The solution to these problems partly lies in the modern cloud computing concept (Shen *et al*., 2019), which provides end users access to the virtual resources of a single system that controls, distributes, and balances the load between computational nodes and applications (Wu and Buyya, 2015). Here, to ensure compliance with the limitation on the total amount of computing resources, it is necessary to use additional models and algorithms to optimize the placement of objects and data in the information system and form the order of service requests according to the selected criteria (Jayanetti *et al*., 2022; Khan and Santhosh, 2022). One of the promising innovations in this area may be the use of artificial neural networks, which potentially provide data processing and searching-specific fragments according to a given algorithm for the automated formation of the necessary dynamic flow (Wu *et al*., 2020). The relevance of implementing and improving such complexes is due to the following.

- The ability to create a holistic picture of the system state, allowing the evaluation of service delivery through the creation of universal "virtual services" and a logical graph, which makes it possible to expose the dependence of the states of actual monitoring objects on the graph
- The ability to work with virtually all formats used in a content delivery network and use data uploading from external sources that affect the quality-of-service delivery
- The innovative video segment analysis solution based on machine learning not previously used in such complexes of data storage, processing, and forming

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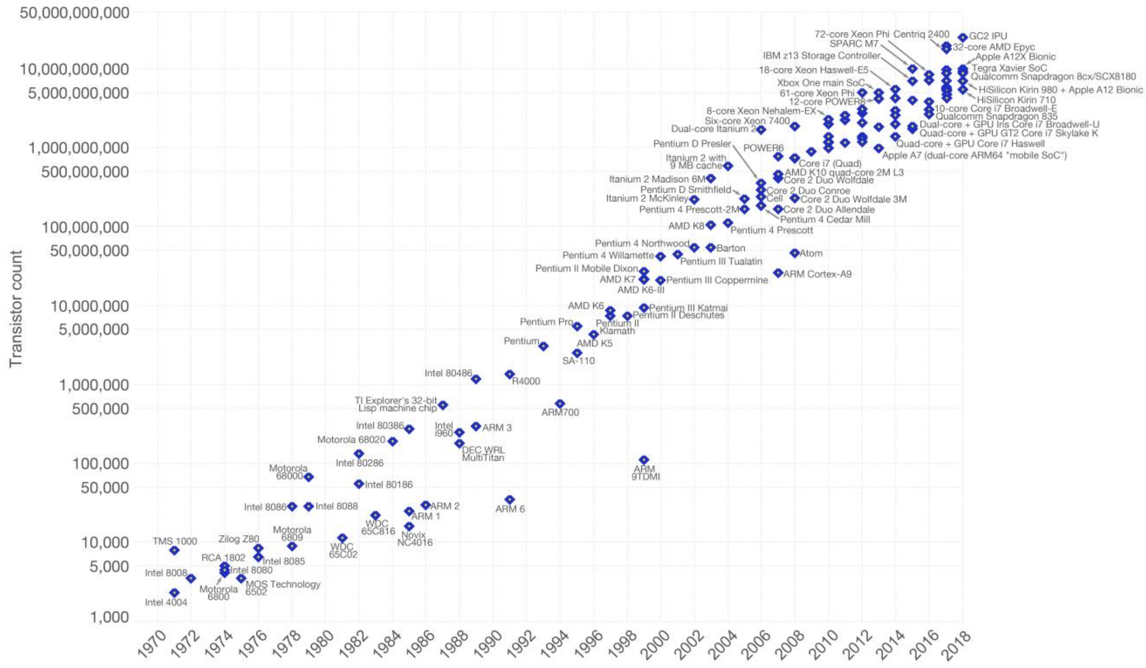

Fig. 1: Logarithmic dependence of the number of transistors on a microprocessor chip on time

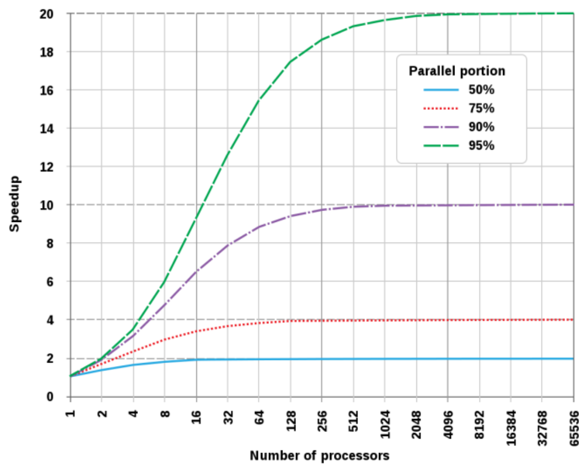

Fig. 2: Illustration of Amdahl's law

Another advantage of such complexes is the availability of automated distributed monitoring (Hsieh and Hung, 2009), which makes it possible to:

- Calculate the status of the service provided to subscribers
- Inform the operator in real-time about abnormal situations at the monitoring object

Such complexes can provide the automation of the business process of monitoring the quality-of-service delivery (Almiani *et al*., 2022), improving the quality of operation services and signal delivery services – reducing the time-of-service unavailability and ensuring a proactive response to a potential emergency or quality degradation before the immediate impact on the quality of services and end users (Sahu *et al*., 2021). Also, they can increase the labor productivity of operating service personnel in service maintenance (Soni and Kumar, 2022), optimize the topology, and reduce the transmission delay in specialized networks (Alexandrov *et al*., 2022).

The conducted review and analysis show the relevance of developing the following promising proposals on the functional structure and technical characteristics of such complexes of multiformat media data storage and processing.

Proposals on the Functional Structure of Promising Complexes for Storing and Processing Multiformat Media Data

For the efficient use of complexes for storing and processing multiformat media data, they must provide:

- Receiving data from external sources
- Checking the quality of the received data
- Data adaptation and maintenance to a single format
- Data cataloging (sorting the data according to the criteria)
- Providing data logistics (storage, movement, conversion into different formats)
- Data processing (searching by image and video sequences, sound sequence, and transcribing)
- Providing access to the complex data for external users to familiarize them with the content directly

– Providing access to the data of the complex to external users for linear broadcasting

Based on the above conditions, the paper authors developed a scheme of the functional structure of promising complexes for storing and processing multiformat media data (Fig. 3).

The chosen method of managing microservices makes it easy to scale the system. each microservice is a node of a computational graph. To automate the deployment and scaling of the system in environments with support for containerization, the use of Docker software, which is the industry standard, is provided.

Approaches were chosen that allow the implementation of distributed algorithms and the corresponding platform. To work with units of media content, an object model of the storage system was chosen, which removes restrictions on the number of stored objects.

The applied methods of data logistics using an open-source Remote Procedure Call (GRPC) system will allow using a single protocol for the entire system and ensures guaranteed delivery of information. Importantly, the GRPC system provides features such as authentication, bidirectional streaming, flow control, blocking or non-blocking bindings, and cancellation and timeouts. It generates cross-platform client and server bindings for many languages. This approach is used to connect services in a microservice architecture style and connect mobile devices and browser clients to back-end services.

To ensure the security of the system, the use of JSON Web Tokens (JWT) is provided. These are server-generated tokens containing basic information about the respective end user. The set of data it carries is mainly composed of email id, user id, password, login details, etc. As the name implies, all records created with it are stored in JSON format. It's worth noting here that the JWT information is easy to use for the client. It also uses cryptography effectively. JWT provides the best results when used in an environment that requires partial information transformation for any unverified client.

In addition, it should be noted that so far widely used neural networks such as multilayer perceptron's do not have several properties that would be useful for systems working with copper. These shortcomings are devoid of recurrent neural networks, which can use their internal memory to process sequences of arbitrary length. In this regard, for context recognition in media data, within the framework of this project, it is planned to use neural networks with Long Short-Term Memory (LSTM), which have gained popularity and were able to bring speech recognition to a new level, showing a significant improvement compared to traditional models (Fernández *et al*., 2007).

Let us consider each module in more detail.

The data aggregation module must perform data sorting according to specific criteria (Fig. 4).

The software component of registry and user authentication must perform the following functions:

– Creation of user accounts
– Authentication of users
– Authorization of users
– Logging of user actions

The database must perform the following functions:

– Storing the metadata
– Changing the metadata
– Processing the metadata

The software component of report generation must perform the following functions:

– Generation of reports at the user interface
– User interaction with the database

The software component of the contextual search of audiovisual sample data must perform the following functions:

– The contextual data search on audiovisual samples
– Interaction with the software component of report generation
– Use neural network technology

The use of the most modern neural networks in the developed complex will ensure the detection of age markers in media data with an accuracy of at least 85% and the accuracy of transcribing an audio sequence into text will be at least 83%.

The software component of data presentation must perform the following functions:

– Interacting with the Graphical User Interface software component
– Sending data from the user to the server
– Processing of data on the server
– Receiving data and formatting it into a readable form

The software component of the graphical user interface must perform the following functions:

– Controlling the complex through user actions
– Data entry by the user
– Displaying data

The data logistics module must sort data according to specific criteria, store data, move data, and convert data into various formats (Fig. 5).

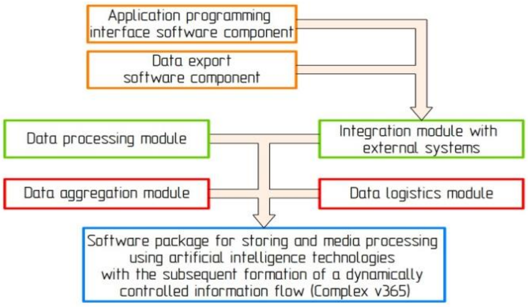

Fig. 3: Functional structure of promising complexes for storing and processing multiformat media data

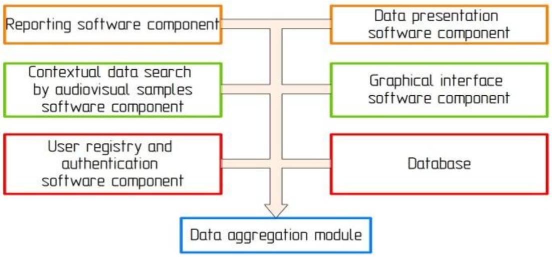

Fig. 4: Components of the data aggregation module

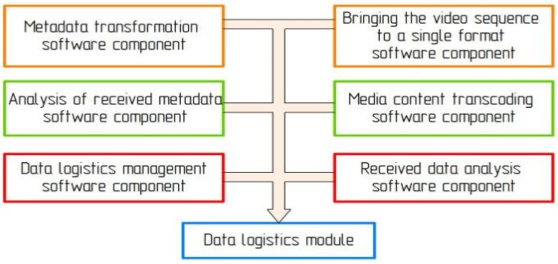

Fig. 5: Components of the data logistics module

The software component of data logistics management must perform the following functions:

- Aggregation of user requests
- Distribution of requests to the executing components
- Aggregation of the data on the job performance
- Generation of reports on the work progress

Below is an example of the workflow of the software component of data logistics management as part of the data logistics module (Fig. 6).

Figure 6 shows the software operating procedures denoted by the following numbers:

1.1 – Receiving user requests to perform tasks via the GRPC protocol
2.1 – Sending user requests to the database with the assignment of a unique Identification number (ID "GUID"), translating task statuses translated by the ETCD manager
3.1 – Translation to the distributed KV–Database (ETCD) to assign a key-value pair for each ID, forming requests for ETCD by Protocol Buffers for serializing structured data (transmission) with subsequent distribution of requests to the executing components (manipulators)
4.1 – Translation of task statuses
5.1 – Translation by ETCD manager of statuses of performed tasks to Multicast Listener Discovery (MLD) PC via the Application Programming Interface (API)
6.1 – Generation of reports on the status values of the performed task in progress and error messages

The software component of metadata analysis should check the quality of the received metadata for compliance with predefined user requirements.

Below is an example of the workflow of the software component of metadata analysis as a part of the data logistics module (Fig. 7).

Figure 7 shows the program operating procedures denoted by the following numbers:

1.1 – Receiving a user command to import metadata from *.xml files
2.1 – Import metadata from *.xml file
3.1 – Translation of metadata or error messages into the database

The software component of media content transcoding must convert the media content into a user-defined format.

The software component of metadata conversion must convert the metadata into a user-defined format.

The software component of the video conversion to a single format must perform the following functions:

- Converting the video content into a user-defined format
- Converting the content into a user-defined format
- Converting metadata into a user-defined format

The data processing module must perform the following functions:

- Image data retrieval
- Data retrieval by the video sequence
- Searching for data on the audio sequence
- Transcribing audio and video data
- Use the neural network technology (Fig. 8)

The software component of audio sequence processing and analysis must perform the following functions:

- Audio analysis
- Processing of the audio sequence according to the user - predetermined requirements

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– Generation of necessary metadata

The software component of image processing and analysis must perform the following functions:

– Image analysis
– Image processing according to the user's predefined requirements
– Generation of necessary metadata

The software component of video sequence processing and analysis must perform the following functions:

– Video content analysis
– Processing the video sequences according to the user's predefined requirements
– Generation of necessary metadata

The software component of metadata generation must generate additional metadata to ensure an advanced data search.

The integration module with external systems must interact with external systems and provide data access to external customers for direct viewing content and linear broadcasting (Fig. 9).

The software component of the data export must perform the following functions:

– Data preparation for external systems
– Data export to external systems

The software component of the application programming interface must perform a user interaction with the complex.

Based on the above proposals on the functional structure of promising complexes for storing and processing multiformat media data, some proposals on their technical characteristics are developed.

Proposals on the Technical Characteristics of Promising Complexes for Storing and Processing Multiformat Media Data

The complex promising for elaboration serves to provide automated round-the-clock control over the distribution of information in broadcasting networks with the ability to organize the control of different types of networks and to automate processes related to control and supervisory activities and information monitoring in terms of compliance with legislation in the field of communications. The main tasks of such a complex are the following:

– Ensuring continuous round–the–clock monitoring of broadcasting in analog and digital standards and automated identification of specified information and abnormal situations
– Ensuring control and supervisory activities as part of the data analysis process
– Obtaining, collecting, and structuring storage of information to ensure the data monitoring process
– Providing analytical information on the data flow status, grouped by place, time, and source

Based on the main objectives and the proposed functional structure, we compiled a list of proposals on the technical characteristics of promising complexes for storing and processing multiformat media data.

The input data should be:

– Audio data: Files in wav, mp3 formats
– Audiovisual data: Files in mp4, mov, mxf, avi formats
– Visual data: Files in mxf, mov formats
– Graphic data: Files in png, tga, bmp formats
– Descriptive data: Text files in xml format encoded utf8
– Subtitles: Files in srt and stl formats

Metadata can be generated by analyzing the obtained materials and describing them manually or using a data processing module.

The output data for the complexes should be the data provided at the user's request:

1) Audiovisual works in the form of files, graphic files
2) Text accompanying materials
3) Reports on object state statistics

– A summary report generated manually (on request) or automatically (on schedule), displayed at the administrator's user interface
– A summary report generated manually (by request) or automatically (by schedule) in *.XLS, *.XML, *.CSV, *.PDF formats
– For the complete operation, the complexes must provide the following temporal characteristics of operation
– Operating mode in general-7 days a week, 24 h a day
– Total acceptable downtime should not exceed 8 h per month, including service and maintenance works

The probability of the complex failure-free operation during 8 h should be not less than 99.9%, provided the network (communication of software components with the database) and hardware health.

The complex must meet the following requirements for the recovery time after failure:

– The average recovery time after failure caused by failure (malfunction) of the complex itself shall not exceed 20 h
– The recovery time after failure caused by power failure (and/or other external factors) of technical means non-fatal failure (not crash) of the operating

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system, subject to technical and software operation conditions, should not exceed 20 h
- Recovery time after failure caused by malfunction of technical means, or fatal failure (crash) of the operating system must not exceed the time required for troubleshooting and reinstallation of software
- Controlling the input and output information during any operation, including control for erroneous input data and checking for numerical data admissibility, ensures the reliable functioning of the complex using the following indicators
- Mean Time Between Failures (MTBF) (time to complete restart of the complex or complete reloading of the operating system) is not less than 1000 h
- The Probability of No-Failure operation (PNF) of the complex is not less than 0.96 per 1000 h
- The operating mode of the complex in general-7 days a week, 24 h a day
- The maximum allowed run time for any failures and malfunctions should not exceed 4 h. This value should not include the deployment and configuration of the system and special software on the server, data recovery using the last backup, the time for solving problems with the technical support, and recovery of the operating system
- The allowable downtime per month should not exceed 8 h, including service and maintenance works
- The results of the complex experimental operation should confirm these requirements
- The criteria for failure and limit state of the complex promising for elaboration are the following
- Failure of a complex is its performance failure with the main functions stopped or disturbed
- The limit state of the complex is its state when due to hardware or software damage, it ceases to satisfy the requirements on data storage time, information processing speed, the maximum number of users, or other requirements

To confirm the requirements for the reliability indicators of the complex promises for elaboration, the calculation method is applicable according to the corresponding programs and methodologies based on the results of the acceptance tests.

The complex promising for elaboration must meet the following requirements for information integrity:

- Data backup and recovery must ensure data integrity in routine and the emergency operation
- Data integrity must be ensured in all emergencies

Emergencies include

A. System-wide software or application software failure
B. Loss of power supply due to a failure in the electrical power network

- To preserve the data stored and coming into the complex, special maintenance facilities should be a part of the database, which provide

a) Creating one complete weekly data backup
b) Restoring the data to a complete state using the backup
c) Creation of a data archive
d) Data recovery through unarchiving

- In the event of information failures, the complex should warn the operator by a modal notification (requiring the operator's confirmation) and record it in the technical protocol of the complex with the time of the failure and its parameters

The proposed characteristics, compared with the existing known solutions, will be able to solve the main problems of promising complexes for storing and processing multiformat media data.

Note that the proposals presented in the article on the characteristics and architecture of promising complexes have limitations in the form of the main hypotheses initially adopted in this study:

- Promising systems for storing and processing multi-format media data should simultaneously distribute and balance the load between various multimedia services under the conditions of physical limitations of computing resources
- The advantage of telecommunication complexes compared with traditional multiviewers for receiving and displaying video and audio signals should be the possibility of complete instrumental analysis and control of the parameters of each input signal

The survey carried out allowed us to identify the following promising areas for further research:

1) Increasing the speed of processing and reliability of data storage by adapting and modifying known algorithms, which will increase the efficiency and increase the market potential of the solutions being developed
2) Development of effective software for multi-format data transmission and integration with existing diagnostic equipment
3) Processing and recognition of images using artificial intelligence algorithms for use in telemedicine, the urgent need for accelerated development which was identified in the context of the recent global COVID-19 pandemic (Mehraeen *et al*., 2022; Shamsabadi *et al*., 2022)

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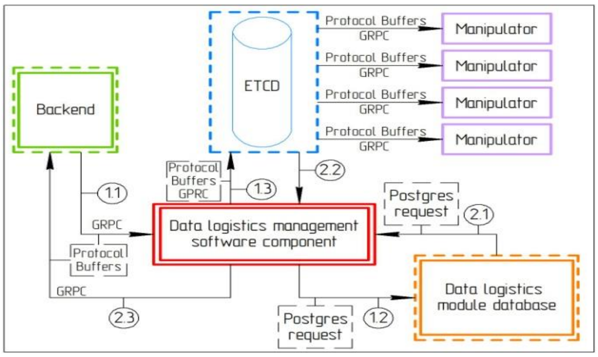

Fig. 6: Software workflow as part of the data logistics module

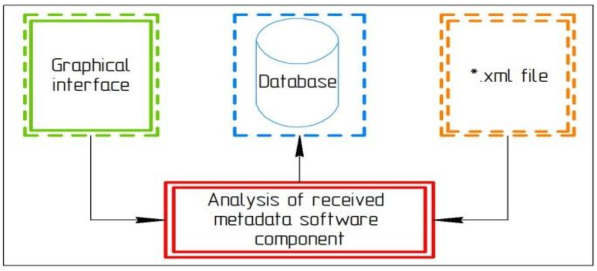

Fig. 7: Workflow of the software component of received metadata analysis

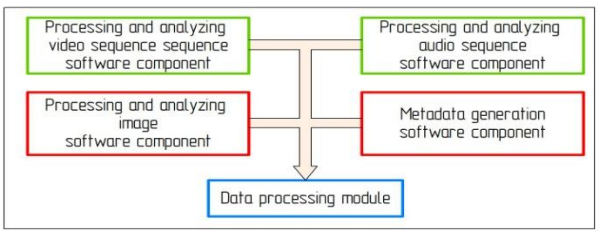

Fig. 8: Components of the data processing module

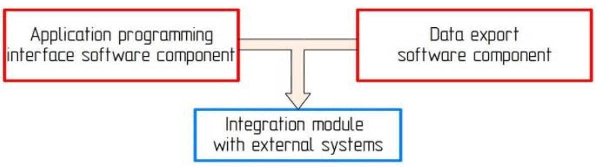

Fig. 9: Components of the integration module with external systems

Conclusion

The relevance of the development of complexes for storage and processing of multiformat media data is demonstrated. Based on the laws of Moore, Amdahl, and Gustavson-Barsis, it is shown that when implementing and improving complexes for multiformat media data, it should be considered that the increase in productivity should be ensured not only by increasing computing power and parallelization but also by optimizing the software used choosing its architecture, adequate technical requirements, optimization of the algorithms used.

Based on this, this study presents a list of promising proposals for the functional structure of complexes for storing and processing multiformat media data and defines the main modules and their characteristics. Additionally, a list of promising proposals on the technical characteristics of complexes for storing and processing multiformat media data is presented.

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Author's Contributions

Vladimir Zhanovich Kuklin: Is responsible for conceptualization, review, and edited the manuscript draft, supervising, and administering the project.

Islam Alexandrovich Alexandrov: Conducted formal analysis and investigation; prepared the manuscript draft.

Alexander Alexandrovich Umyskov: Carried out the validation, data curation, and visualization.

Abas Khasanovich Lampezhev: Is in charge of the methodology and software.

Ethics

The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

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