Software and hardware complex for the development and research of methods for broadband access to multimedia resources and the Internet

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D D Dmitriev[1, 3], A B Gladyshev[1], V N Ratuschnyak[1] and O B Grithan[2]

[1]Siberian Federal University, 79 Svobodny pr., 660041, Krasnoyarsk, Russia
[2]JSC Academician M.F. Reshetnev Information Satellite Systems, 52, Lenin Street, Zheleznogorsk, Krasnoyarsk region, 662972, Russia

[3]E-mail: dmitriev121074@mail.ru

Abstract. The article describes the features of the organization of satellite communication systems in the separated and northern territories of Russia. For such conditions, satellite communications should support traditional voice and broadband Internet access. A promising method for implementing broadband access is to combine the DVB and TCP / IP protocol families without modifying them, taking into account their features. This will allow for the translation of data streams with all the advantages of DVB protocols in the most popular modes at the world level at present: many information sources – many information recipients. The use of the DVB-S2X standard for access to multimedia resources and the Internet requires the adjustment of IP packets for user packets of the UP (User packet) DVB-S2X standard. To support multiple access for different users, it is possible to use TDM time division multiplexing of UP packets. A hardware-software complex for the development and experimental research of methods for broadband access to multimedia resources and the Internet is described. The proposed software architecture provides the user with tools for conducting experimental studies of the studied methods. One of the important advantages of the proposed architecture is the breakdown of functionality into modules, which will allow parallel development of all modules at the same time and simplify the process of creating software.

1. Introduction

Currently, satellite communications is an important part of the information and telecommunications space of the Russian Federation. Satellite communications should ensure access to information resources throughout the Russian Federation, including the northern and Arctic territories with undeveloped terrestrial communications infrastructure.

Today, one of the most relevant areas of economic development in Russia is the development of the Arctic region. This region has significant natural resources and is of crucial geopolitical importance. Of particular relevance is the development of the Arctic region during the competition of the leading world powers in this region, as well as the development of the Northern Sea Route and cross-polar air routes [1]. The need to develop the Arctic is one of the directions of national development of Russia, which is reflected in official documents of the Government of the Russian Federation. For the full integration of the Arctic region into a single information space in Russia, it is necessary to create a developed telecommunication network in this territory. This network should

provide users with a range of services, including fixed satellite communications, mobile satellite communications, direct audio broadcasting, and broadband Internet access.

The most important need of a modern person is the possibility of unhindered access to multimedia resources and the Internet. These are social networks, distance learning, public services and many other opportunities provided by the Internet, without which modern life is no longer possible. The active development of digital technologies with Internet access has a significant impact on the space surrounding a person: everyday life, education, industrial production, mobile applications, medicine, trade, services, everyday life, leisure. The volumes of information circulating in networks are increasing exponentially, which requires more and more resources to organize full-fledged broadband access.

2. Providing broadband Internet access using satellite channels

Transport Protocols TCP / IP (Transmission Control Protocol / Internet Protocol) have become widespread worldwide as a medium for exchanging information between networked computers. But the more high-performance modern protocols of the DVB family support the transmission of only digital multiprogram broadcasting and do not provide for the transmission of digital data streams. The two main reasons for this are that DVB protocols are unidirectional (i.e., no return response channel is provided) [2, 3, 4]. The second reason is the impossibility of a session mode of operation, which is necessary when interacting with computers, working with servers, databases and knowledge, etc. The combination of two popular technologies will allow data packets to be transmitted over the existing satellite channels DVB-S2 by modifying the TCP / IP protocol. The solution of this problem will significantly simplify the architecture of satellite communications terminals.

The development of methods and fundamental solutions for interfacing hardware based on the DVB and TCP / IP protocol families without modifying them, but taking into account their features, is an urgent task. This will allow for the translation of data streams with all the advantages provided by structures based on DVB protocols in the most popular modes at the present world level: many sources of information - many recipients of information. The solution of this problem will significantly simplify the architecture of satellite communication terminals and use the existing DVB-S2 communication channels for transmitting data via TCP / IP.

The implementation of broadband access to multimedia resources and the Internet by transmitting data via TCP / IP using DVB-S2 standards requires the solution of several new scientific and technical problems. It is necessary to develop a set of methods:

- formation, reception and processing of TCP / IP protocol data using signal-code constructions of the DVB-S2 standard in a wide frequency band;
- fine-tuning and implementing TCP / IP protocol data for a DVB-S2 standard frame as a payload for various high-speed modes of signal-code constructions with noise-resistant codes BCH and LDPC and QPSK, 8PSK, 16APSK, 32APSK modulations;
- receiving TCP / IP protocol data from a demodulated and decoded DVB-S2 frame.
- TDM time division multiplexing applications for DVB-S2 physical frames in VCM and ACM modes.

The use of the DVB-S2X standard for access to multimedia resources and the Internet requires the adjustment of IP packets for user packets of the UP (User packet) DVB-S2X standard. To support multiple access for different users, it is possible to use TDM time-division multiplexing of UP packets to form BBFRAME DVB-S2X with selected frame characteristics in VCM or ACM modes (figure 1). The filter decay coefficient is also selected, such as a raised cosine, the speed of the BCH and LDPC encoders to form a FECFRAME, interleaving, and selecting a signal constellation to implement the XFECFRAME physical frame.

Each UP is complemented by a 1-byte CRC-8 cyclic parity check code. UP timeslots are presented as a single Generic Continous Stream. Then this stream is cut into data blocks called Data Field and a BB (Baseband) header is attached to each Data Field, as shown in figure 2.

The BB header consists of 80 bits and contains the following fields:

- MATYPE determines the type of input data, SIS or MIS, ACM / CCM modes and Roll-off factor;
- UPL (User Packet Length) determines the length of the UP;
- DFL (Data Field Length) determines the length of the Data Field;
- SYNC copies CRC8 bytes;
- SYNCCD – information about the indentation of the fully entered UP (which completely entered the Data Field, as shown in figure 2);
- CRC-8 verification code for the entire BB frame.

Then successive BB frames are scrambled with a pseudo-random binary sequence using the LFSR linear register with the associated polynomial $1 + x^{14} + x^{15}$.

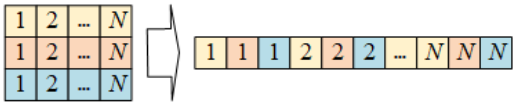

Figure 1. TDM UP packet multiplexing.

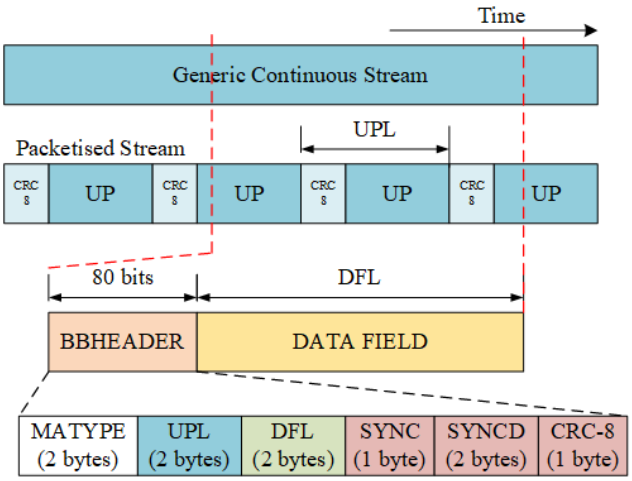

Figure 2. BB framing.

3. Software and hardware complex for research of broadband access methods

The software and hardware complex is intended for the development and experimental research of methods for broadband access to multimedia resources and the Internet in remote, northern and Arctic territories of the Russian Federation [5-8].

The hardware and software complex consists of:

- a transceiver simulating a ground segment;
- a transceiver simulating an airborne segment;
- measuring equipment;
- a control computer with software that provides control of hardware and simulation model, as well as display and documentation of the results.

The software and hardware complex provides the following functions:

- the ability to set input influences and tuning parameters for the complex;
- complex hardware management;

- display of research results;
- documentation of the results of the study.

To implement these functions, the software architecture of the complex was developed, as shown in figure 3.

The proposed architecture of the software complex provides the user with tools for conducting experimental research on methods of broadband access to multimedia resources and the Internet. One of the important advantages of the proposed architecture is the breakdown of functionality into modules, which allows parallel development of all modules at the same time and simplifies the process of creating software.

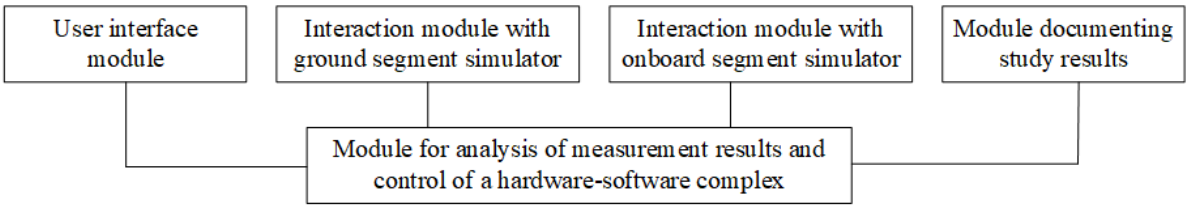

Figure 3. Complex software architecture.

For experimental research, the software and hardware complex provides data exchange at two levels:

- exchange of Internet packages at the level of software and hardware complex – user modem over TCP / IP;
- DVB-S2 signal exchange at the level of a software and hardware complex – a space communications device.

Exchange of data packets to the user modem level – software and hardware complex occurs on a dedicated channel of predetermined width. A feature of this exchange is the redistribution of channel resources between active users in order to increase the exchange rate. To achieve this effect, an add-on has been developed over the existing TCP / IP protocol stack. It allows you to transmit within the frame the center frequency and bandwidth used for the receiver / transmitter of the Internet modem and a request-response system for permitting data transmission.

The software and hardware complex receives data from user modems; on their basis, it calculates and allocates frequency bands for active modems. Then, all active modems receive messages that contain the necessary settings for their transceiver devices. User modems reconfigure their transmitting and receiving devices and transmit ready-to-exchange messages to the software and hardware complex (messages are already transmitted at the recommended frequencies).

The indicated functionality of the software and hardware complex is implemented using reconfigurable transceiver devices. A software-defined reconfigurable NI-USRP radio device was used as a ground station simulator. NI-USRP is controlled by computer. To reduce the signal processing time, the Kintex-7 FPGA DSP debug board is used as a remote unit.

To study the methods of broadband access to multimedia resources and the Internet with various schemes for constructing a data transmission channel (using repeaters with and without signal processing), the PXIe-5840 transceiver and the ZynqUltraScale + RFSoC debug board are used as relay simulators. The PXIe-5840 transceiver implements a bent-pipe (active, without demodulation-modulation) repeater model. On the ZynqUltraScale + RFSoC debug board, a repeater model with a reconfigurable FPGA is implemented. The structural diagram of the software and hardware complex in is presented in figure 4.

To conduct experimental studies of the developed methods of broadband access to multimedia resources and the Internet, all the hardware of the complex operates on software management, which is based on elements of a computer model of a satellite communications terminal. The computer model is implemented in the LabView graphical programming environment with partial use of dynamic libraries (DLLs) developed using the Matlab software. The block diagram of the model is shown in figure 5.

A computer model consists of the following elements:

- satellite communication terminal no. 1, which includes TCP / IP servers, access point, receiver and transmitter;
- satellite communication terminal track no. 1 – onboard repeater, which consists of an uplink and a downlink;
- two-channel onboard repeater;
- satellite communication terminal route no. 2 — an on-board repeater, which consists of an uplink and a downlink;
- satellite communication terminal no., which includes a receiver, a transmitter, an access point and a client part, including 20 clients.

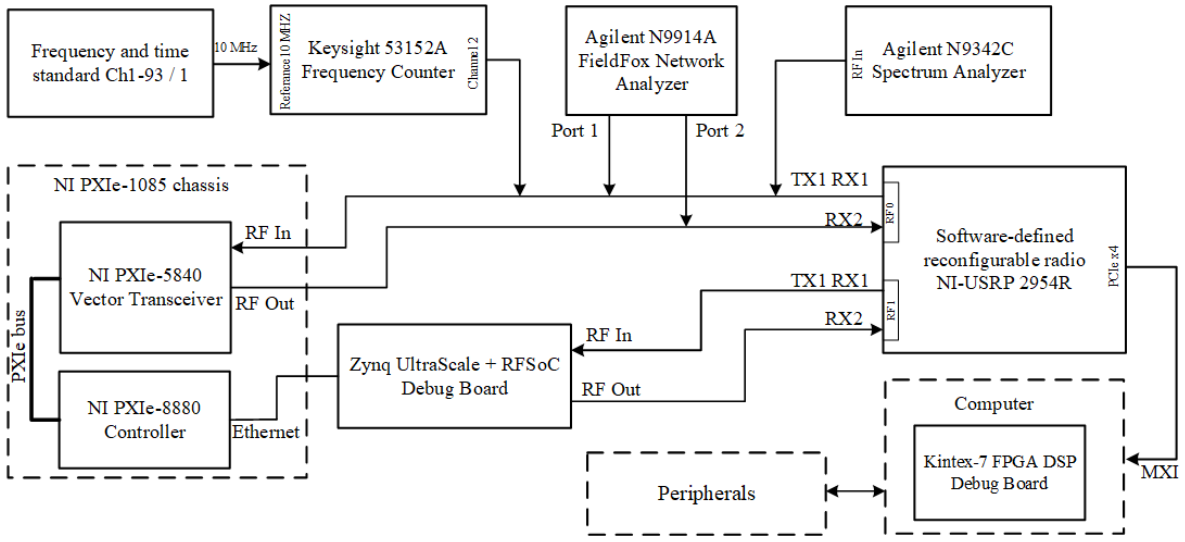

Figure 4. Block diagram of a software and hardware complex for the development and research of methods for broadband access to multimedia resources and the Internet.

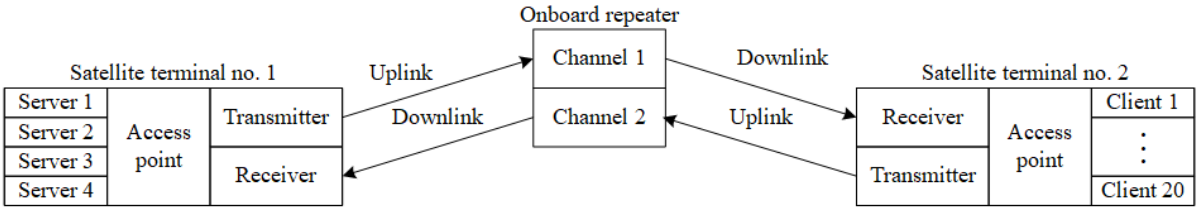

Figure 5. Block diagram of a computer model.

The computer model operates in accordance with the DVB-RSC2 standard for broadband interactive communications. It implements access from twenty remote clients located on the satellite communication terminal no. 2 to any of the four servers located on the satellite communication

terminal no. 1. For remote access, the TCP / IP network protocol is used, which is used as the transport protocol for the DVB-S2 digital satellite communications standard. The TCP / IP protocol provides data transmission with confirmation (logical connection), that is, numbers the packets and confirms their receipt with a receipt, and in case of loss organizes a retransmission. For this reason, each of the satellite communication terminals contains a receiver and a transmitter for organizing duplex communication via an onboard repeater.

At the application level, the HTTP protocol is used. For the convenience of calculating BER, PER, the text WEB page filled with a pseudo-random sequence of numbers is used as the transmitted data from the server to the client.

To uniquely identify the client with the server, each of the twenty remote clients has its own custom IP and MAC address for the client. Each of the four servers has an expanded set of customizable parameters:

- IP and MAC address of the server;
- MAC address of the client (for targeted data transmission or broadcast packets);
- subnet mask and main gateway.

4. Conclusion

The most promising way to organize a communication system for broadband Internet access is to develop solutions for pairing hardware based on the DVB and TCP / IP protocol families without modifying the latter, taking into account their features. This will allow for the translation of data streams with all the advantages provided by DVB protocols in the most popular modes at the world level at present: many information sources – many information recipients. Transmission of digital data streams based on the TCP / IP complex – developed driver – DVB using satellite telecommunications will greatly simplify the task of providing information to remote areas.

The method presented in the article allows you to fine-tune IP packets for user packets of the UP (User packet) DVB-S2X standard. To support multiple access for different users, it is possible to use TDM time-division multiplexing of UP packets to form a BBFRAME DVB-S2X with selected frame characteristics in VCM or ACM modes.

Experimental studies of the methods of broadband access to multimedia resources and the Internet provide a developed hardware-software complex.

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