LABORATORY 10

Laboratory of Communications Network Theory

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The leading researchers of the laboratory include:

Dr.Sc. (Math.)	N. Vvedenskaya	Dr.	V. Mikhailov
Dr.Sc. (Techn.)	A. Kuznetsov	Dr.	I. Orlov
Dr.Sc. (Techn.)	I. Levshin	Dr.	V. Polyakov
Dr.Sc. (Techn.)	B. Tsybakov	Dr.	A. Rubinov
Dr.	N. Likhanov	Dr.	S. Fedortsov

DIRECTIONS OF ACTIVITY:

- network reliability theory;
- self-similar traffic in ATM networks;
- multiple access packet communications networks;
- asymptotical investigation of large queueing systems;;
- coding and signal processing for storage systems;
- imitational processes for hydroacustic information transmission systems.

MAIN RESULTS

In Lab.10 there are three scientific groups: 1) Polesskii V. P., Rubinov A. R., Kuznetsov A. V.; 2) Likhanov N. B., Vvedenskaya N. D., Tsybakov B. S., Fedortsov S. P., Mikhailov V. A.; 3) Levshin I. P., Orlov I. A. Polyakov V. G. is an independent individual.

The groups develop the contemporary communication network theory. The first group uses and elaborates discrete mathematics methods, the second group and third one uses elaborates probabilistic methods.

V. P. Polesskii continued his investigations in the theory of system and network reliability bounds. His approach to the theory is motivated from revealing the reliability combinatorics. It was described in electronic journal "Information Processes", 2001, v. 1, no. 2. The contemporary state of the monotone systems reliability bounds theory was described by V. P. Polesskii in [1]. The theory is the first level of the network reliability bounds theory. V. P. Polesskii constructed [2] new record efficiently computabled two-sided bounds for monotone systems reliability. The bounds use groups of minimal paths or groups minimal cuts (for example, the shortest minimal paths or the smallest minimal cuts). The results were announced on the Third International Conference "Mathematical Methods in Reliability" held in the June of 2002, Norway. A program to compute the two-sided bounds for the monotone system reliability was done by the Institute of Information Science of RAS. The program can allow to find the best practical method to choice minimal path groups and minimal cut groups in order to obtain good bounds.

The ability to transport information at very high data rates has come the realization that traditional assumptions on the stochastic nature of network traffic flows are inadequate. Recent studies have demonstrated that long-range-dependence is an important characteristic of traffic flows in current networking infrastructures. Numerous studies have shown that in the presence of such traffic the tail of the buffer overflow probability has an asymptotic power-law decay compare with conventional traffic models where the tail of the buffer overflow probability is exponential. For this reason, it is interesting to know what classes of inputs define the transition between the two types of behavior. Subexponential models are considered as one approach. For these models N. Likhanov get [3] the exact asymptotic decay rate for the buffer overflow probability.

N. D. Vvedenskaya continued [4-7] the investigation of large queueing systems. The topic is a traditional one for our institute, members of different laboratories are involved in consideration of large systems. This theme is closely connected with investigation of the modern telecommunication systems. The mathematical models of systems with dynamic routing are considered, that is the routing that depends on the current state of the system. The tool of the work is the estimation of the network performance parameters, in particular the conditions under which the network is not overloaded. Thus the load-balance routing protocols are proposed and estimated. The open Jackson-type network is the main model. That is the system where new tasks approach upon the system and each task after being served by a server leaves the system with some probability or is resent to some server to be served again. The asymptotical methods are used, the limit systems that appear when the number of servers is growing to infinity are considered. The work uses the methods of theory of probability (for the systems with finite number of servers) and the methods of differential (by new terminology functional) equations (for the limit system model with infinite number of servers). In both cases nontrivial mathematical problems have to be solved. In particular we met a new type of differential (functional) equations with nonlocal coefficient that depend on solution values at fixed points. Interesting boundary value problems for differential equations appear also in TCP-type queuing systems. These systems are very popular nowadays because of use of TCP-type protocols in modern telecommunication networks.

The wide spread of digital wireless telephony and the growing request for support of real-time applications have led to an increasing demand for wireless data and file transmission. The third generation (3G) of CDMA mobile communication networks is beginning to meet the demand. Fundamental problems need to be solved for such mobile communication networks to operate efficiently. One of the problems is finding optimal scheduling algorithms for the transmission over the fading downlink channel from a base station to mobile users. The problem was not considered in the classical queuing and scheduling theories. The problem is solved by B. S. Tsybakov for a specific system. It is assumed that the base station is involved in a transmission of a finite number N of files. There are no new file arrivals before completion of transmission of these N files, or if there are new arrivals, they do not intervene in the ongoing transmission of N files. In general case, at any time, the transmission algorithm knows the lengths of remaining files and knows the transmission rates in all N downlink channels. For the system, the three specific algorithms are considered. One algorithm chooses the channel having the maximum rate in slot, the next algorithm transmits the file having the minimal ratio (remaining file length/channel rate), and the last is the time-sharing algorithm. Using the additive property, the work gives the equations for finding the average delay and average transmission time for the algorithms. It is show how the equations can be solved recursively. Then it is presented a general algorithm or a class of algorithms that includes the three considered algorithms as special cases. After definition of the class, it is possible to state a problem of finding of optimal algorithm. The optimal algorithm is found. The importance of optimal algorithm is in both the possibilities of its implementation and it's using as a reference for comparison with other algorithms. Examples of numerical comparison of considered algorithms are given. The examples show that the dynamic time-sharing algorithm is almost as good as the optimal algorithm, and that sometimes, it is even better than the algorithm that transmits over the best channel in slot. The results are published in [8, 9].

In paper [10] of B. Tsybakov and A. Rubinov the conflict-avoiding codes are presented. They can be used as protocol sequences for successful packet transmission over the collision channel without feedback. We give a relation between conflict-avoiding codes and known codes are discussed. The upper bounds to maximum code size and three particular code constructions are given.

A. V. Kuznetsov completed (see [11-17]) the study of the BER characteristics of the structured LDPC codes under different conditions for perpendicular and longitudinal channels. Designed simplified encoders and decoders for the structured LDPC codes. Encoders and decoders for some rll-codes were designed.

The information technology of the automatic prognosis of the quality of the information transmission channels, like communications, search and discovery of the marine and submarine ships, navigation, telemetry and others, of the moving marine objects is considered. The technology, based on the methods and means of the simulation modelling, in the Institute for Information Transmission Problems is developed by I. P. Levshin. The technology includes the elaboration and investigation of the mathematical and simulation models of the complicated physical media of the information transmission signals. The methodic of the separate and joint elements of the information transmission channels construction is developed. The data banks of the geophysical and geological parameters, used in the model, are considered [18, 19].

I. A. Orlov developed the method of the analysis of the noiseproof for the underwater acoustics communications system on the base of the algorithm of the computer simulation model of the underwater acoustics communications system and of the generation algorithm of the stochastic transfer function of the hydroacoustic medium. Examples of results of the analysis are presented [18, 20].

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