According to Little's theorem, the mean wait until successful transmission, \( MW \), is
\[
MW = \frac{x}{\lambda a}.
\] (15)

For a dynamic protocol of multiple random access in communications networks with notification of clashes, we have thus found some basic characteristics: the throughput \( S \), which is given by (9); the distribution of the number of repeated-call sources and the channel status, \( \pi(x) \) and \( \pi_v(x) \), given by (14); the parameters \( \beta \) and \( \epsilon \) here, which are given by (10) and (11); and the mean wait \( MW \), which is given by (15). We have demonstrated that the distribution of the number of active user stations is asymptotically exponential.

In summary, we have examined a satellite communications system with a dynamic access protocol with notification of clashes. We have studied it by mathematical modeling, and we have found some basic probabilistic and temporal characteristics of the network: the throughput of a communications channel, the message wait time, and other quantities.

The approach taken here is of wider applicability, in the analysis of communications networks, in the analysis of signals in lidar sounding in the photon-counting regime, in the analysis of sonar and radar systems, in the modeling and study of computer-controlled systems for physical experiments, etc. It thus becomes possible to derive theoretically the most important physical and technical characteristics of these systems.

LITERATURE CITED


RESTRICTIVE SPLINES FOR DATA PROCESSING

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We propose a new type of polynomial spline for data processing - the restrictive spline. The construction of this type of spline generalizes known ones and differs from them by the fact that the conditions of matching the elements of the spline at its nodes contain restrictions (in the form of inequalities) on the value of the maximum permissible discontinuity of the matching derivative of corresponding order (standard splines do not contain such restrictions). Varying the strength of the restrictions, one can smoothly transform the spline from one defect to another thorough intermediate states, which do not exist for standard splines, extending the possibilities of the spline approximation. We propose a stable calculating scheme for constructing restrictive splines.

During his research, an experimental physicist inevitably faces observational errors and also a priori indeterminacy with respect to the character of the investigated physical law.

In some cases, a type of the investigated physical law may be known a priori from theoretical speculations or from previous experiments, and one should find only numerical values for the curve parameters. For example, a statistical distribution can be described

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by a Gaussian curve, whose parameters are the average and dispersion; the shape of a spectral line can be also described by a Gaussian curve, whose parameters are the position of the maximum, its amplitude and width, etc.

In other cases, the shape of a curve describing an investigated law is unknown a priori, but from physical speculations some properties of this law may be known, for instance, continuity and smoothness, stepless changes, restriction in curvature, and so on. In this case, the problem of experimental data processing is to fit an appropriate analytical or graphical dependence that best approximates the empirical law by considering the properties of this law which are known a priori. Here, due to observational errors, noises, and distortions, an investigator faces a contradictory problem to maximally smooth out the empirical dependence in order to minimize the influence of measurement errors and, simultaneously, not to lose the features of the investigated physical effect, the physical law. Usually, this can be achieved by choosing as a hypothetical law, which connects together physical values in an experiment, a sufficiently flexible system of functions or curves that have the characteristic properties (as seen by the observer) of the investigating physical law, together with using the methods of mathematical statistics which permit one to maximally reduce the influence of random experimental factors on the data processing results.

In research, one uses various types of dependencies which, to some extent, satisfy the investigated physical laws. One of a sufficiently general class of functions, used in different physical investigations, is the class of power functions, i.e., polynomials. The investigated physical law is described here by a fragment of a power series (a power polynomial) to desired order, and the coefficients of the polynomial are determined by the methods of mathematical statistics from the condition that the polynomial best fits the experimental data and from the statistical characteristics of experimental errors. This class of dependencies is convenient due to the fact that the parameters of the polynomial (its coefficients) comprise the approximate dependence in a linear form which significantly simplifies their computations. To approximate complex dependencies, one needs polynomials with higher powers, which unfortunately, leads to a computational non-stability during the fit with experimental data. A more flexible and comfortable method for approximating experimental data is the formalism of polynomial splines [1], which requires polynomials of low powers, even for approximating very complex dependences, due to piecewise-polynomial approximation. Here, the linear dependence on the coefficients remains.

A polynomial (in particular, cubic) spline can be generated by "gluing" polynomial fragments (in particular, cubic parabolas) at the nodes of some net (not necessarily regular), such that the values of the neighboring polynomials and some number of their first derivatives agree at the nodes [1]. These conditions, defined at the nodes of the spline, are called the matching conditions of the spline elements. One says that the defect of the spline equals zero if the spline itself and all its derivatives are continuous everywhere in the defined region of the spline. If higher derivatives at the nodes of the spline have discontinuities, then one says that the spline has a defect equal to the number of discontinuous derivatives. Polynomial splines are especially widely used in fields of investigations where one has to process large masses of data (in geophysics, oceanography, hydrometeorology [2], etc.). However, the construction of polynomial splines, traditionally used in physical researches, have one significant disadvantage: varying the defect of a spline changes abruptly (discretely) its behavior, which restricts the possibilities for spline approximation.

Below, we propose a new type of polynomial spline, a restrictive spline, which is free from this disadvantage.

1. New Type of Spline for Data Processing

The construction of the type of spline, which we present here, generalizes known constructions of splines and differs from them by the matching conditions for the spline elements at the nodes. In these conditions, we introduce restrictions (in the form of inequalities) on the value of the maximum permissible discontinuity for matching derivatives of corresponding order. Standard splines do not contain such restrictions. The matching conditions take the form

\[
d^\kappa S_{i,t}(t_i + 0)/dt^\kappa = d^\kappa S_{i,t}(t_i - 0)/dt^\kappa + \kappa! \delta_{\kappa,i-\Delta+1} u_t, \quad |u_t| \leq c_t \quad (\kappa = 0, \nu - \Delta + 1; \ i = 0, n - 1; \ 0 \leq \Delta \leq \nu; \ t \in [0, T]), \tag{1}
\]