THE FOREWORD OF THE SCIENTIFIC EDITOR

The intensive transition to systems of digital format data processing and transmission which has begun at the end of the last millenium for today becomes more and more scale and is characterized rather fast and substantial increase of requirements to reliability of figures. Undoubtedly, the leading part in maintenance of a high level reliability and quality of the discrete information transmission is played with modern methods of noiseproof coding.

For more than semicentenial history of development of the theory and technics of noiseproof coding the basic methods and approaches to the decision of the main problem of this scientific discipline - maximum simple and simultaneously very effective decoding - repeatedly and rather essentially varied. If all over again leading directions of the theory of coding were interesting development of error correcting algorithms on the basis of finite spheres of algebra then very simple and clear majority methods investigations there has come an era of the Viterbi algorithm. This algorithm was from the theoretical point of view maximum complex, with total search, but so effective, that the significant period of time all development of the coding theory and concrete error correcting device creation for a satellite communication have been concentrated on this method. To tell the truth, it was impossible to use long codes for decoder Viterbi because of a problem exponential decoder complexity growing with a code length increase.

Followed then the period of effective realization of concatenated coding methods has successfully come to the end with introduction in technical equipment of communication of concatenated codes on the base of convolutional codes and Read - Solomon codes. Thus, as well as the theory predicted, in practice really appeared, that concatenated codes allowed at smaller complexity of decoding in comparison with initial non-concatenated methods to provide simultaneously and much higher characteristics of a noiseproof feature. However, despite of the big progress in the theory and in microelectronic technology, characteristics of systems of coding and the subsequent decoding up to the end of 80th years remained still far from theoretically possible limits.

Only turbo codes occurrence has shown to experts in 1993 , that practically full use of digital communication channel capacity appears already quite real technical problem. Sets of a turbo similar and some other codes have proved, that ways much more an effective capacity utilization of very expensive Space, satellite and many other digital channels have already really appeared, than it was possible till now. The Gaussian channels signal power at use some codes of these classes can be very close to the limit value, that one is defined by the basic theoretical restriction: equality of code speed and the channel capacity. Experts could not think at all about anything similar before. And in fact already for a long time it was known, that decrease in allowable signal power for channels results in huge economic benefit. In 1980 the known American expert, the author of classical books on the coding theory

E.Berlekemp in one of the reviews asserted, that each one decibel of power reduction in communication channel is estimated in one million dollars. At modern scale of digital networks an economic effect of coding application has increased in many tens times. Clearly, that it occurs as a result of essential increase of transmission speed, significant decrease in the sizes of very expensive aerials, growth communication distance , and also many other rather important advantages of communication systems using coding. It also defines importance for all branches of telecommunications of works on creation of effective decoders. Many tens annual international conferences on noiseproof coding practically always appear among the most actual.

However the last decade has identically shown, that sets of a turbo similar and some other codes nevertheless have not solved a problem of complexity of decoding. Moreover, today even proceeding rather fast development of microelectronic technologies does not allow to assert, that in quite high-speed channels it is possible to recommend application of a turbo codes. In many cases decoders for these codes will be much slower, than it is required, or excessively expensive.

The new very effective decision of a problem of decoding complexity at simultaneous realization of high power characteristics of systems of coding on the basis of multithreshold decoders (MTD) is clearly stated in the book of the known native expert in the field of noiseproof coding Dr. Sc. V.V.Zolotarev. The first invention patent at this surprisingly simple and very effective method, was handed to him in1972. For the expired period he creates the universal theory of this unique method, and the set of concrete development of MTD decoder was introduced into systems of communication of various purpose{assignment} with very high characteristics.

MTD algorithms, as well as the majority of decoders for a turbo of codes, are iterative procedures. However the turbo codes have appeared for 20 years after multithreshold algorithms which and those years, and now continue to develop rather dynamically and are intensively patented. But the most important consists that majority procedures allow to realize actually their full parallel work. It is main condition for high-speed MTD decoders creation with a very high power characteristics.

Other major advantage of MTD algorithms before many other error correcting procedures will be, that they possess property of strict growth of plausibility of the decisions during all process of error correction in the messages deformed by noise. Any strict proofs of similar unique properties for other methods of decoding till now are not known. Certainly, at achievement by the MTD decoder of the most plausible decision it appears optimum one, such which usually demands full searching all possible decisions as it very elegantly carries out, in particular, Viterbi algorithm (VA). But MTD complexity, certainly, remains linearly growing function of used code length. Therefore MTD, as against decoder Viterbi, easily operates with very long codes. This property provides high noise characteristics and a large code gain.

At perusal of the book there is clear to readers one more important, even «dramatic» circumstance: why algorithm MTD was not open by foreign experts. In 70th years they published the huge number of results on repeated attempts of messages decoding in which some part of the erroneous symbols already has been corrected at the first step of decoding. Quite obvious it becomes after perusal offered to the reader given theoretical and applied research.

The reasons of absolute leadership of MTD decoding methods will consist in the following.

1. Anyone up to the author of this book did not try to solve a problem of such change of elementary known majority decoding methods, that it become possessed ability of strict decisions improvement at all changes decoding symbols. Really, the aspiration to make a very simple algorithm a method which is almost not distinguished from optimum very complex procedures, can be only praiseworthy, however it is also extremely risky. But such problem has been stated by the author - and it was solved!

2. One more, ideologically much more difficult problem was simultaneously decided - and solved (!) by the author. He had to do the new deep analysis the reasons of errors grouping at the output of the majority decoder. This effect called the error propagation (EP) does useless repeated attempts of decoding, as proved to be true by many experimental works on coding in 70th years. And actually it followed on the basis of the deep and all-round analysis of the decoder EP maximum to minimize it and to find such codes in which the EP is not shown almost. And this problem has been solved by the author also by the mathematical methods earlier never used in the field of noiseproof coding.

Only the simultaneous decision of these twointerconnected problems has allowed to create special codes and iterative procedures with the elementary majority functions which even at very high noise levels could improve gradually during many iterations reliability of the messages accepted from the channel and in overwhelming majority of cases to find optimum decisions.

But actually the success of MTD algorithms development is connected with the decision of one more classical problem: finding functional of very large number of variables optimum. As the author completely fairly specifies, an opportunity of a variation of a lot of codes and decoders parameters, in particular, weights of checks, values of threshold elements and differential properties in used codes polynomials of creates additional conditions for improvement of MTD decoders characteristics. Such adjusted elements in decoders can be many hundreds and even several thousands. But after a correct choice of these elements it appears, that the automated computer optimization of the decoder parameters at a stage of its designing appreciably improves and so high enough characteristics of multithreshold algorithm in general without any increase in final complexity and volume of calculations of the real developed decoder with such improved parameters. Let's notice, that statement of this third problem for other systems of decoding even cannot be imagined, as it can arise

only in parallel with the decision of first two problems of effective and simple decoding described above for MTD algorithms.

Thus, the success of the theory and applied achievements in the field of simple and effective decoding by means MTD is determined by the simultaneous successful decision of three above-stated most complicated problems, each of those is anyhow connected with the decision of functional optimization problems for the case of the large variables number. Absence of satisfactory decisions even one of them, undoubtedly, repeatedly would lower value of possible achievements in the field of iterative majority decoding circuits as all their characteristics in this case would be rather and rather modest.

In the book very unusual to traditional ways of decoding other methods are submitted also. Actually all of them serve an overall objective put in this book: to the maximal growth of efficiency of the decoder at the minimal complexity of its circuit. It is possible to attribute to them concatenation with the elementary codes of the parity check control, results on parallel coding, and also codes with the allocated branches.

Special place among the algorithms offered by the author must be stated also for the first time described by him MTD decoders for nonbinary codes. They are essentially better on the efficiency then for Read - Solomon (RS) codes, remaining so simple in realizations, as well as their binary analogues. Surprisingly, but for many decades of coding theory development of such obvious generalization of majority methods on nonbinary digital data streams and has not been made by any researcher, except the author of this monograph. Advantage nonbinary MTD before RS codes appears at once so significant, that it is actually possible to say that 20 years open more back these new codes and algorithms open completely new epoch in processing the symbolical information. Thus, for this MTD type simply in general there are no other methods of any complexity which could be compared to it on efficiency. As well as by development of other useful approaches to error correction, the author has reached very significant results for nonbinary codes only due to using to much longer codes, than unique RS codes accessible now. Certainly, at nonbinary MTD extremely small complexity of decoding inherent in majority methods is kept. These codes also will find wide application in sphere of processing, storage and data transmission.

Interestingly and that MTD the algorithms intended for struggle against channel errors, without any changes it is possible to apply successfully and to increase of a noise immunity, and for data compression, i. e. for the simultaneous decision of the second major problem of the information theory - coding of some kinds of sources.

At last, it is necessary to emphasize, that all described MTD algorithms are so simple in realization and simultaneously highly effective, that exactly their program versions have successfully passed strict tests and have been accepted to use in systems of special digital TV, and for codes corresponding to them procedure of standardization is started.

It was supposed, that occurrence of the given book should take place at 10 years earlier. Then now it would be possible to speak about its next advanced edition. However its author, nevertheless, during all this time tried to acquaint the scientific and technical public with new development in the field of coding. The important event for domestic experts became an appearance in 2004 referance book of V.V.Zolotarev and G.V.Ovechkin «Noiseproof coding. Methods and algorithms» in publishing house «Hot line - Telecom». It has allowed to expand considerably sphere of MTD algorithms applications and appreciablly to speed up their development for a wide range of applied problems.

The large contribution to development of the theory and technology of coding have brought also becoming regular author's reports at traditional annual International conferences on digital signal processing in Moscow. Specialized bilingual web-site of the Space Research Institute, Russian Academy of Sciences www.mtdbest.iki.rssi.ru on multithreshold decoding methods is well known also and becoming already very big. There are submitted more than two hundreds units of theoretical, methodical, educational and demonstration materials on this algorithm, including even a series of the special computer movies especially brightly showing in dynamics feature of MTD decoders work. This site is widely known to experts.

Finishing representation of this book, certainly, rather unusual on the methods and results about the best for last years achievements of domestic researchers in the field of noiseproof coding, it would be desirable to wish the author and his pupils of the further successful work on a vast field of high-quality digital networks. The publication such monograph important for the theory and technology of communication in the time of intensive transition of the world community to completely digital methods of creation, storage, processing and data transmission, certainly, will speed up all processes of communication systems perfection and the further growth of quality of information service in our society.

Fast modern development of coding technology and continuous growth of opportunities of element base will expand even more sphere of application both MTD algorithm itself, and sets of its updatings. Certainly, and for some other methods realization of decoding will appear quite accessible problem even if now they still seem too difficult. But it is abundantly clear, that only those methods of coding which most purposefully and economically spend the computing resources for the decision of a task of distortions correction in digital data streams, really appear extremely fast, the most effective and accessible to wide application in communication networks.

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