Technical English

For Information and Communication Engineering

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Unit Four

Digital Communication over Fading Channels

enamor	迷住，使迷恋
notion	概念，想法
closed-form expression	闭合表达形式
motivate	推动，激励
impetus	动力
backbone	骨干，脊椎
the literature	文献（总称）
fading	衰落
diversity	多种多样，多样性
insight	洞察力，深入内部
heretofore	迄今
proceedings	论文集
spawn	酿成，大量生产
millennium	千年

integral	积分
integrand	被积函数
virtue	优点，功效
coherent	相干的，连贯的
differential	微分的
compendium	纲要，概要
myriad	无数的，种种
journal	期刊，杂志
collocate	使位于一处
copious	很多的，丰富的
compilation	编辑物，编辑成的书
constraint	限制，约束
benchmark	基准，测试基准
ensue	跟着发生，继起
cellular wireless	蜂窝式无线（通信）
expertise	专长

理论家总是迷恋于如何将他们的研究结果表达成闭合形式这样一种观念

Regardless of the branch of science or engineering, theoreticians have always been enamored with the notion of expressing their results in the form of closed-form expressions. Quite often, the elegance of the closed-form solution is overshadowed by the complexity of its form and the difficulty in evaluating it numerically. In such instances, one becomes motivated to search instead for a solution that is simple in form and simple to evaluate.

由于其形式的复杂性以及数值求解的困难性而变得逊色

寻求并能够找到一种统一方法来解决如何评价广义衰落信道中数字通信性能的问题正是撰写本书的动机

导出这些简单的替代形式所用方法应该也适用于 …

A further motivation is that the method used to derive these alternative simple forms should also be applicable in situations where closed-form solutions are ordinarily unobtainable. The search for and ability to find such a unified approach for problems dealing with evaluation of the performance of digital communication over generalized fading channels is what provided the impetus to write this book, the result of which represents the backbone for the material contained within its pages.[1]

其结果就是本书所包含材料的核心内容

早年的研究结果主要处理简单信道模型

For at least four decades, researchers have studied problems of this type, and system engineers have used the theoretical and numerical results reported in the literature to guide the design of their systems. Whereas the results from the earlier years dealt mainly with simple channel models (e.g., Rayleigh or Rician multipath fading), applications in more recent years have become increasingly sophisticated, thereby requiring more complex models and improved diversity techniques.[2]

而近年来的应用则愈来愈复杂，因此需要更复杂的模型和改进的分集技术

随之而来的是解析解的复杂性

Along with the complexity of the channel model comes the complexity of the analytical solution that enables one to assess performance. With the mathematical tools that were available previously, the solutions to such problems, when possible, had to be expressed in complicated mathematical form which provided little insight into the dependence of the performance on the system parameters.[3]

这些数学表达式极少能提供关于系统性能是如何依赖于参数的深入解释

直到最近才有人给出统一的方法

Surprisingly enough, not until recently had anyone demonstrated a unified approach that not only allows previously obtained complicated results to be simplified both analytically and computationally but also permits new results to be obtained for special cases that heretofore had resisted solution in a simple form.[4]

迄今为止无法求得简单解的特殊情况

以讲座形式首次于1998年9月发表在*IEEE Proceedings*上

This approach, first presented to the public in a tutorial style article in the September 1998 issue of the *IEEE Proceedings*, has spawned a new wave of publications on the subject that, we can foresee based on the variety of applications to which it has already been applied, will continue well into the new millennium.[5]

这种方法引起了一大批关于该课题的论文发表，…，这一势头将持续到新的千年

使用数字通信系统误码率分析中出现的经典函数的不同表达方法

The key to the success of the approach relies on employing alternative representations of classic functions arising in the error probability analysis of digital communication systems (e.g., the Gaussian Q-function and the Marcum Q-function) in such a manner that the resulting expressions for average bit or symbol error rate are in a form that is rarely more complicated than a single integral with finite limits and an integrand composed of elementary (e.g., exponential and trigonometric) functions.[6]

对平均误码率或平均符号错误率的表达形式几乎不比具有有限积分限、以基本函数为被积函数的单一定积分形式更复杂

借助于

By virtue of replacing the conventional forms of the above-mentioned functions by their alternative representations, the integrand will contain the moment generating function (MGF) of the instantaneous fading signal-to-noise ratio (SNR), and as such, the unified approach is referred to as the *MGF-based approach*.

将包含瞬时信噪比的距生成函数（MGF）

其中相干通信、差分相干通信、部分相干通信和不相干通信都涉及到了

In dealing with application of the MGF-based approach, the coverage in this book is extremely broad, in that coherent, differentially coherent, partially coherent and non-coherent communication systems are all handled, as well as a large variety of fading channel models typical of communication links of practical interest. Both single- and multi-channel reception are discussed, and in the case of the latter, a large variety of diversity types are considered.

对实际感兴趣的通信链路具有典型性的种类繁多的衰落信道模型

得到系统的平均误码率（BER）和符号错误率（SER），并以容易求值的形式表示

For each combination of communication (modulation/detection) type, channel fading model, and diversity type, the average bit error rate (BER) and/or symbol error rate (SER) of the system is obtained and represented by an expression in a form that can readily be evaluated. All cases considered correspond to real practical channels, and in many instances the BER and SER expressions obtained can be evaluated numerically on a hand-held calculator.

一个有关各种问题结果的大纲，这些结果在很大程度上是数字通信标准教科书中所没有的

In accomplishing the purpose set forth by the discussion above, we focus on developing a compendium of results that to a large extent are not readily available in standard textbooks on digital communications. Although some of these results can be found in the myriad of contributions that have been reported in the technical journal and conference literature, others are new and as yet unpublished.

在技术刊物和会议文献中发表的不计其数的成果中找到

相当一部分引用的文献是来自1999年发表的资料

Indeed, aside from the fact that a significant number of the reference citations are from 1999 publications, many others refer to papers that will appear in print in the new millennium. Whether or not published previously, the value of the results found here is that they are all collocated in a single publication with unified notation and, most important, a unified presentation framework that lends itself to simplicity of numerical evaluation.[7]

它们是以统一的符号，更重要的是以统一的描述框架出现在同一本书中，从而有助于简化数值计算

这些材料已经包含在这一领域的许多优秀著作中了

In writing this book, our intent was to spend as little space as possible duplicating material dealing with basic digital communication theory and system performance evaluation, which is well documented in many fine textbooks on the subject. Rather, this book serves to advance the material found in these books and so is of most value to those desiring to extend their knowledge beyond what ordinarily might be covered in the classroom.

对于那些要想要将他们的知识扩展到通常课堂覆盖内容以外的读者最有价值

本书应该对于 … 的研究生，以及 … 的实践工程师有很大的吸引力

In this regard, the book should have a strong appeal to graduate students doing research in the field of digital communications over fading channels as well as to practicing engineers who are responsible for the design and performance evaluation of such systems. With regard to the latter, the book contains copious numerical evaluations that are illustrated in the form of parametric performance curves (e.g., average error probability versus average SNR).

对于后者（工程师们）

在通信类型、衰落信道、分集的各种组合之间

The applications chosen for the numerical illustrations correspond to real practical channels, therefore the performance curves provided will have far more than academic value. The availability of such a large collection of system performance curves in a single compilation allows the researcher or system designer to perform trade-off studies among the various communication type/fading channel/diversity combinations so as to determine the optimum choice in the face of his or her available constraints.[8]

使研究者或系统设计者能在 … 之间进行对比研究和取舍，从而在他（她）所面临的限制之下作出最佳的选择

Our discussion on digital communication over fading channels will be concentrated on four important topics. The first is to introduce the subject of communication system performance evaluation and consider various types of fading channel models and modulation/detection schemes that together form the overall system.

介绍通信系统性能评估这一问题，考虑各种衰落信道模型以及调制/检测方案

计算表征通信系统误码性能的某些积分

The second is concerned with some alternative forms of the classic functions mentioned above. Having defined these functions, we will proceed to show how they can be used to (1) evaluate certain integrals characteristic of communication system error probability performance, and (2) find new representations for certain probability density and distribution functions typical of correlated fading applications.

寻求对于相关衰落应用具有典型性的某些概率密度和分布函数的新形式

关于单信道和多信道接收中各类衰落信道模型和调制/检测方案的性能评估

The third topic is the "heart and soul", or the primary focus, of our discussion, which is on the performance evaluation of various types of fading channel models and modulation/detection schemes for both single and multiple channel reception. Before presenting this comprehensive performance evaluation study, however, we will provide derivations of the optimum receiver structures corresponding to a variety of the fading parameters (i.e., amplitude, phase, delay).[9]

推导相应于各种衰落参数的最佳接收机结构

Several of these structures may be deemed as too complex to implement in practice; nevertheless, their performances serve as benchmarks against which many suboptimum but practical structures will be compared later.[10]

它们的性能可用作参照标准，多种次最佳的实用结构将与之进行比较

我们将考虑 … 的问题，然后应用统一的方法去研究 …

Finally, the fourth topic deals with practical applications. We will consider the problem of optimum combination (diversity) in the presence of co-channel interference and then apply the unified approach to study the performance of single- and multiple-carrier direct-sequence code division multiple-access (DS-CDMA) systems typical of the current digital cellular wireless standard.[11] The theory developed in these discussions for uncoded communication can also be extended to error-correction-coded systems.

当前数字蜂窝移动通信标准中典型的单载波和多载波直接序列码分复用系统的性能

In summary, the authors know of no other textbook currently on the market that addresses the subject of digital communication over fading channels in as comprehensive and unified a manner as is done herein.[12]

以本书这样完整统一的方式讨论衰落信道中的数字通信问题

就作者所知

In fact, prior to the publication of this book, to the authors' best knowledge, there existed only two works (the textbook by Kennedy and the reprint book by Brayer) that like our book are totally dedicated to this subject, both more than a quarter of a century old. Although a number of other textbooks devote part of their contents to fading channel performance evaluation, by comparison with our book the treatment is brief and therefore incomplete. In view of the above, we believe that our book is unique in the field.

结合课文的思考题

- What is a closed form expression?
- Why closed form expressions are difficult to find and inconvenient to use?
- What are the four topics this book is concerned about?
- Why the author considers their work is unique?

Exercises: Translation

- **A desired output power spectrum can be obtained by quickly moving through frequencies where the desired power spectrum is low, and slowly moving through frequencies where the desired power spectrum is high.**

  要求的输出功率谱可以这样来获得：迅速地扫过要求功率谱较低的频段，缓慢地扫过要求功率谱较高的频段。

- **A very commonly used method of microwave measurements is based on the study of a standing wave pattern formed along the line because of the interference of incident and reflected waves.**

  一个很常用的微波测量法是基于对驻波波型的研究，这种驻波由入射波和反射波之间的干涉而沿着传输线形成。

Exercises: Translation

- **In the beginning, computers were used to process only numerical information, but majority of our information is non-numerical in nature and very little is known about its description and processing.**

  一开始计算机只是被用来处理数值信息，而我们的大多数信息都是非数值性质的，而且人们对这些信息的描述和处理所知甚少。

- **It is rare that the optimization will be achieved in only one step, and usually many iterations around the analysis-error-adjustment loop will be required for obtaining a satisfactory result.**

  只经一步就达到优化的情况是罕见的，为得到满意的结果通常要围绕“分析－误差－调节”的循环进行多次迭代。