

Solutions to selected problems from Chapter 3

- 3.1 The information sequences $u = [u_0 \ u_1 \ u_2 \ u_3]$ are encoded into codewords v of length $n = 8$, using a systematic encoder. If we assume that the systematic positions in a codeword are the last $k = 4$ positions, then codewords have the form

$$v = [v_0 \ v_1 \ v_2 \ v_3 \ u_0 \ u_1 \ u_2 \ u_3],$$

and the systematic encoding is specified by

$$v = uG_{sys}; \quad G_{sys} = [P \ | \ I].$$

From the given set of parity-check equations we immediately obtain the generator and the parity check matrices. For example, we can start with the parity check matrix H and recall that every row in H represents one parity-check equation, and it has ones on the positions corresponding to the symbols involved in that equation. Thus, we have

$$H_{sys} = [I \ | \ P^T] = \left[\begin{array}{cccc|cccc} 1 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 \end{array} \right] \quad (1)$$

$$G_{sys} = [P \ | \ I] = \left[\begin{array}{cccc|cccc} 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 1 & 0 & 0 & 0 & 1 \end{array} \right] \quad (2)$$

To find the minimum distance analytically, we use the property that the minimum distance of a binary linear code is equal to the smallest number of columns of the parity-check matrix H that sum up to zero (see Corollary 3.2.2 in the book). Hence, we find that:

- there are no two identical columns in $H_{sys} \Rightarrow d_{min} > 2$
- there are no groups of 3 columns that sum up to 0 $\Rightarrow d_{min} > 3$
- there exists a group of 4 columns (for example, columns 1,2,3,6) that sum up to 0 $\Rightarrow d_{min} = 4$.

- 3.2 General structure of a systematic encoder for a linear (n, k) block code is shown in Figure 3.2 in the book. Based on the parity check equations from the previous problem, the systematic encoder for the $(8, 4)$ code has the structure as shown in Figure 1.

- 3.3 Syndrome vector is obtained from the received sequence $r = [r_0 \ r_1 \ \dots \ r_7]$ using the parity check matrix of the code:

$$s = [s_0 \ s_1 \ s_2 \ s_3] = rH^T.$$

Error Control Coding Solution Costello

Alan G. Konheim



Error Control Coding Solution Costello:

Error Control Coding Shu Lin, Daniel J. Costello, 1983 Completely updated to cover latest developments this text provides a bridge between introductory courses in digital communications and more advanced courses in information technology It presents state of the art control techniques *Essentials of Error-Control Coding Techniques* Hideki Imai, 2014-06-28

Essentials of Error Control Coding Techniques presents error control coding techniques with an emphasis on the most recent applications It is written for engineers who use or build error control coding equipment Many examples of practical applications are provided enabling the reader to obtain valuable expertise for the development of a wide range of error control coding systems Necessary background knowledge of coding theory the theory of error correcting codes is also included so that the reader is able to assimilate the concepts and the techniques The book is divided into two parts The first provides the reader with the fundamental knowledge of the coding theory that is necessary to understand the material in the latter part Topics covered include the principles of error detection and correction block codes and convolutional codes The second part is devoted to the practical applications of error control coding in various fields It explains how to design cost effective error control coding systems Many examples of actual error control coding systems are described and evaluated This book is particularly suited for the engineer striving to master the practical applications of error control coding It is also suitable for use as a graduate text for an advanced course in coding theory **Error-Correction Coding and Decoding**

Martin Tomlinson, Cen Jung Tjhai, Marcel A. Ambroze, Mohammed Ahmed, Mubarak Jibril, 2017-02-21 This book discusses both the theory and practical applications of self correcting data commonly known as error correcting codes The applications included demonstrate the importance of these codes in a wide range of everyday technologies from smartphones to secure communications and transactions Written in a readily understandable style the book presents the authors twenty five years of research organized into five parts Part I is concerned with the theoretical performance attainable by using error correcting codes to achieve communications efficiency in digital communications systems Part II explores the construction of error correcting codes and explains the different families of codes and how they are designed Techniques are described for producing the very best codes Part III addresses the analysis of low density parity check LDPC codes primarily to calculate their stopping sets and low weight codeword spectrum which determines the performance of these codes Part IV deals with decoders designed to realize optimum performance Part V describes applications which include combined error correction and detection public key cryptography using Goppa codes correcting errors in passwords and watermarking This book is a valuable resource for anyone interested in error correcting codes and their applications ranging from non experts to professionals at the forefront of research in their field This book is open access under a CC BY 4.0 license *Management of Multimedia Networks and Services* John Vicente, David Hutchison, 2004-12-15 This book constitutes the refereed proceedings of the 7th IFIP IEEE International Conference on Management of Multimedia Networks and Services MMNS 2004 held in San

Diego CA USA in October 2004 The 16 revised full papers presented were carefully reviewed and selected from 84 papers submitted The papers are organized in topical sections on multimedia over wireless adaptive multimedia streaming novel protocols in wireless systems scalable multimedia systems MPLS bandwidth provisioning and control distributed systems management proactive quality of service multimedia service control and management and mobility control and management

Multimedia Communications, Services and Security Andrzej Dziech,Wim Mees,Andrzej Czyżewski,2020-09-24 This volume constitutes the refereed proceedings of the 10th International Conference on Multimedia Communications Services and Security MCSS 2020 held in Krak w Poland in October 2020 The 24 full papers and 2 short papers included in the volume were selected from 54 submissions The papers cover ongoing research activities in the following topics multimedia services intelligent monitoring audio visual systems biometric applications experiments and deployments Internet of Vehicles. Technologies and Services for Smart Cities Sheng-Lung Peng,Guan-Ling Lee,Reinhard Klette,Ching-Hsien Hsu,2017-11-20 This book constitutes the proceedings of the 4th International Conference on Internet of Vehicles IOV 2017 held in Kanazawa Japan in November 2017 The 19 papers presented in this volume were carefully reviewed and selected from 40 submissions They deal with advances in the state of the art and practice of the IoV architectures protocols services and applications as well as identifying emerging research topics and define the future directions of Internet of Vehicles

Error Correction Codes for Non-Volatile Memories Rino Micheloni,A. Marelli,R. Ravasio,2008-06-03 Nowadays it is hard to find an electronic device which does not use codes for example we listen to music via heavily encoded audio CD s and we watch movies via encoded DVD s There is at least one area where the use of encoding decoding is not so developed yet Flash non volatile memories Flash memory high density low power cost effectiveness and scalable design make it an ideal choice to fuel the explosion of multimedia products like USB keys MP3 players digital cameras and solid state disk In ECC for Non Volatile Memories the authors expose the basics of coding theory needed to understand the application to memories as well as the relevant design topics with reference to both NOR and NAND Flash architectures A collection of software routines is also included for better understanding The authors form a research group now at Qimonda which is the typical example of a fruitful collaboration between mathematicians and engineers *Wireless Technology* Subal Kar,2024-11-13 The text contains all the essential elements of communication principles devices circuits antennas and systems covering the electromagnetic spectrum from KHz to MHz of radio frequency RF that was developed in the formative stage of wireless technology Also the digital revolution that has changed the landscape of modern electronics for wireless technology has been discussed emphasizing the fundamentals including digital computers The presentation of the book is in a concise yet complete way and stresses the physical and technical aspects with application viewpoints but using minimum possible mathematics The book Discusses the historical background of different developments of wireless technology from KHz to MHz and going through the GHz to THz in due perspective to provide a holistic view of the development of wireless

technology from its inception to contemporary times Contains in brief the basic concepts of electromagnetism like Maxwell's wave equation evanescent waves surface waves plasmonic waves that are used in wireless technology in some form or the other Highlights the need for modulation and covers various modulation techniques such as continuous wave and pulse analogue modulation and modulation demodulation systems that were developed in the formative stage of the development of wireless technology in the RF frequency range of KHz to MHz Discusses the physical concepts and application view points of active devices RF transmission lines antennas and systems used at KHz to MHz frequency domain of wireless technology Covers the digital revolution that has changed the wholesale electronic systems of modern wireless technology and the development of digital computers has also been discussed with a brief overview of laptops supercomputers and upcoming quantum computers This overall scenario of historical perspective of wireless technology from KHz to THz and technical developments from KHz to MHz in the RF domain during the formative stage of development of wireless technology including fundamental developments related to digital revolution is expected to attract the interest of the entry level students research scholars professionals and even the general readers alike with a new vision to have a quick yet in depth glimpse of the progress of wireless technology since its inception till today It is primarily written for junior undergraduate students in the fields of electrical engineering electronics and communication engineering wireless communication telecommunication and computer engineering Research scholars and professionals can also refresh their idea of the developments of wireless technology during its formative stage and can get a flavour of the route to modern developments that have taken place henceforth

Performance Analysis and Modeling of Digital Transmission Systems William Turin, 2012-12-06 This book is an expanded third edition of the book Performance Analysis of Digital Transmission Systems originally published in 1990 Second edition of the book titled Digital Transmission Systems Performance Analysis and Modeling was published in 1998 The book is intended for those who design communication systems and networks A computer network designer is interested in selecting communication channels error protection schemes and link control protocols To do this efficiently one needs a mathematical model that accurately predicts system behavior Two basic problems arise in mathematical modeling the problem of identifying a system and the problem of applying a model to the system analysis System identification consists of selecting a class of mathematical objects to describe fundamental properties of the system behavior We use a specific class of hidden Markov models HMMs to model communication systems This model was introduced by C E Shannon more than 50 years ago as a Noisy Discrete Channel with a finite number of states The model is described by a finite number of matrices whose elements are estimated on the basis of experimental data We develop several methods of model identification and show their relationship to other methods of data analysis such as spectral methods autoregressive moving average CARMA approximations and rational transfer function approximations

Resource Management in Wireless Networking Mihaela Cardei, Ionut Cardei, Ding-Zhu Du, 2006-07-06 Following the pattern of the Internet growth in popularity started in the early

1990s the current unprecedented expansion of wireless technology promises to have an even greater effect on how people communicate and interact with considerable socio economic impact all over the world The driving force behind this growth is the remarkable progress in component miniaturization integration and also developments in waveforms coding and communication protocols Besides established infrastructure based wireless networks cellular WLAN sat lite ad hoc wireless networks emerge as a new platform for distributed applications and for personal communication in scenarios where deploying infrastructure is not feasible In ad hoc wireless networks each node is capable of forwarding packets on behalf of other nodes so that multi hop paths provide end to end connectivity The increased flexibility and mobility of ad hoc wireless networks are favored for applications in law enforcement homeland defense and military In a world where wireless networks become increasingly interoperable with each other and with the high speed wired Internet personal communication systems will transform into universal terminals with instant access to variate content and able of handle demanding tasks such as multimedia and real time video With users roaming between networks and with wide variation in wireless link quality even in a single domain the communications terminal must continue to provide a level of Quality of Service that is acceptable to the user and conforms to a contracted Service Level Agreement

Streaming Media Architectures, Techniques, and Applications: Recent Advances Zhu, Ce, Li, Yuenan, Niu, Xiamu, 2010-09-30 This book spans a number of interdependent and emerging topics in streaming media offering a comprehensive collection of topics including media coding wireless mobile video P2P media streaming and applications of streaming media Provided by publisher **Telegeoinformatics** Hassan A. Karimi, 2004-03-15 Telegeoinformatics is a new discipline resulting from the integration of mobile computing with wired and wireless communications geoinformatics including GIS and GPS and remote sensing techniques and technologies Users of telegeoinformatics from every field will need a comprehensive reference to solve multiple types of problems involving local

Hashing in Computer Science Alan G. Konheim, 2010-12-07 Written by one of the developers of the technology Hashing is both a historical document on the development of hashing and an analysis of the applications of hashing in a society increasingly concerned with security The material in this book is based on courses taught by the author and key points are reinforced in sample problems and an accompanying instructor's manual Graduate students and researchers in mathematics cryptography and security will benefit from this overview of hashing and the complicated mathematics that it requires

Mobile Computing C.S.R. Prabhu, 2003 Papers presented at the National Conference on Mobile Computing held at Hyderabad during 11-12 December 2001

The Industrial Information Technology Handbook Richard Zurawski, 2018-10-03 The Industrial Information Technology Handbook focuses on existing and emerging industrial applications of IT and on evolving trends that are driven by the needs of companies and by industry led consortia and organizations Emphasizing fast growing areas that have major impacts on industrial automation and enterprise integration the Handbook covers topics such as industrial communication technology sensors and embedded systems The book is

organized into two parts Part 1 presents material covering new and quickly evolving aspects of IT Part 2 introduces cutting edge areas of industrial IT The Handbook presents material in the form of tutorials surveys and technology overviews combining fundamentals and advanced issues with articles grouped into sections for a cohesive and comprehensive presentation The text contains 112 contributed reports by industry experts from government companies at the forefront of development and some of the most renowned academic and research institutions worldwide Several of the reports on recent developments actual deployments and trends cover subject matter presented to the public for the first time

Networking 2005 Networking Technologies, Services, And Protocols; Performance of Computer And Communication Networks; Mobile and Wireless Communications Systems Raouf Boutaba, 2005-04-27 This book constitutes the refereed proceedings of the 4th International IFIP TC6 Networking Conference NETWORKING 2005 held in Waterloo Canada in May 2005 The 105 revised full papers and 36 posters were carefully reviewed and selected from 430 submissions The papers are organized in topical sections on peer to peer networks Internet protocols wireless security network security wireless performance network service support network modeling and simulation wireless LAN optical networks Internet performance and Web applications ad hoc networks adaptive networks radio resource management Internet routing queuing models monitoring network management sensor networks overlay multicast QoS wireless scheduling multicast traffic management and engineering mobility management bandwidth management DCMA and wireless resource management

Transporting Compressed Digital Video Xuemin Chen, 2005-11-28 The purpose of Transporting Compressed Digital Video is to introduce fundamental principles and important technologies used in design and analysis of video transport systems for many video applications in digital networks In the past two decades progress in digital video processing transmission and storage technologies such as video compression digital modulation and digital storage disk has proceeded at an astounding pace Digital video compression is a field in which fundamental technologies were motivated and driven by practical applications so that they often lead to many useful advances Especially the digital video compression standards developed by the Moving Pictures Expert Group MPEG of the International Organization for Standardization ISO and the International Electrotechnical Commission IEC have enabled many successful digital video applications These applications range from digital video disk DVD and multimedia CDs on a desktop computer interactive digital cable television to digital satellite networks MPEG has become the most recognized standard for digital video compression MPEG video is now an integral part of most digital video transmission and storage systems Nowadays video compression technologies are being used in almost all modern digital video systems and networks Not only is video compression equipment being implemented to increase the bandwidth efficiency of communication systems but video compression also provides innovative solutions to many related video networking problems The subject of Transporting Compressed Digital Video includes several important topics in particular video buffering packet scheduling multiplexing and synchronization

Networks on Chips Giovanni De Micheli, Luca Benini, 2006-08-30 The design of today's

semiconductor chips for various applications such as telecommunications poses various challenges due to the complexity of these systems. These highly complex systems on chips demand new approaches to connect and manage the communication between on-chip processing and storage components and networks on chips. NoCs provide a powerful solution. This book is the first to provide a unified overview of NoC technology. It includes in-depth analysis of all the on-chip communication challenges from physical wiring implementation up to software architecture and a complete classification of their various Network on Chip approaches and solutions. Leading edge research from world renowned experts in academia and industry with state-of-the-art technology implementations trends. An integrated presentation not currently available in any other book. A thorough introduction to current design methodologies and chips designed with NoCs. *2021 International Conference on Security and Information Technologies with AI, Internet Computing and Big-data Applications* George A.

Tsihrintzis, Shih-Jeng Wang, Juon-Chang Lin, 2022-11-29. This book aims to attract researchers and practitioners who are working in information technology and computer science. This edited book is about basics and high-level concepts regarding blockchain technology and application, multimedia security, information processing security of network cloud and IoT, cryptography and information hiding, cyber security and evidence investigations and learning and intelligent computing. It is becoming increasingly important to develop adaptive intelligent computing, energy-aware, secure and privacy-aware mechanisms in high performance computing and IoT applications. The book serves as a useful guide for industry persons and also helps beginners to learn things from basic to advance in the area of better computing paradigm. Our aim is intended to provide a platform for researchers, engineers, academicians as well as industrial professionals from all over the world to present their research results in security-related areas. We believe that this book not only presents novel and interesting ideas but also will stimulate interesting discussions from the participants and inspire new ideas. *Free Space Laser Communication with Ambient Light Compensation* Saleh Faruque, 2021-04-17. This book addresses 5G network capacity requirements with a new architecture for 5G Optical Backhaul Network. The author first describes the challenges for 5G backhaul network requirements and then the details of an Optical Backhaul Network for 5G. The author describes an architecture in which small cells deploy as a cluster, i.e., 3-5 small cells in one cluster where one small cell works as an aggregation point using an optical transceiver to backhaul the aggregated traffic to the nearest optical network unit before it then goes to the core network. This book also illustrates the optical link budget analysis that can be used to determine the availability and the performances of the optical backhaul link in different deployment scenarios and different weather conditions. Provides a single source reference to the basics of free space laser communication with ambient light compensation. Offers timely information blending theory and practice. Written to be accessible to readers with varying backgrounds including numerous illustrations. Provides hands-on experience through practical examples which can be put to work to deploy and optimize cellular networks.

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