[195] Raymond M. Wong, Thomas A. Berson, and Richard J. Feiertag. Polonius: An identity authentication system. In *IEEE 1985 Symposium on Security and Privacy*, pages 101–107, Silver Spring, MD, April 1985. IEEE Computer Society Press. This paper describes an authentication method making use of personal authentication devices known as PassPorts. The devices implement a form on one-time pad encryption. When a user attempts to logon to a host, the host transmits a seven digit challenge. The user keys the challenge along with a PIN into the PassPort and receives a seven digit response. The response is keyed into the terminal, and if it matches what the host expected, the user is authenticated.

[196] C. Wood, W. Banks, S. Guarro, A. Garcia, V. Hampel, and H. Sartorio. *Computer Security: A Comprehensive Controls Checklist*. John Wiley and Sons, 1987.

[197] Charles Cresson Wood. Effective information security with password controls. *Computers and Security*, 2(1):5–10, January 1983. The need for improved password use is discussed in light of several computer break-ins attributed to poor password selection. The author considers the trade-offs between user-friendliness and security, the construction and administration of passwords, and implementation issues.

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[171] Donn Seeley. Password cracking: A game of wits. *Communications of the ACM*, 32(6):700–703, June 1989. This article describes the password cracking techniques employed by the Internet worm. The four steps used by the worm, as well as the fast encryption algorithm used, are discussed. Finally, the author offers his opinions as to whether the worm caused damage, whether it was malicious in nature, and whether publication of worm details further harm security.

[172] Adi Shamir. How to share a secret. *Communications of the ACM*, 22(11):612–613, 1979.

[173] T. Shannon. An introduction to VAX/VMS security mechanisms and techniques. *Computers and Security Journal*, 4(2):39–47, Winter 1987.

[174] Kamaljit Singh. On improvements to password security. *Operating Systems Review (ACM)*, 19(1):53–60, January 1985. This paper describes improvements to operating systems that would make passwords less vulnerable to attack. The first improvement prevents eavesdropping on communications through the use of public-key cryptography. The author proposes a protocol for secure communication. The second improvement is an algorithm allowing the use of long password phrases, which prevent the success of exhaustive password searches.

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[177] Sidney L. Smith. Authenticating users by word association. *Computers and Security*, 6(6):464–470, December 1987. The author proposes the use of word association lists for user authentication. A study of four subjects who were allowed to select their own lists was conducted, and the memorability and security of the lists selected is analyzed.

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[142] Chris Mitchell and Michael Walker. The password predictor – a training aid for raising security awareness. *Computers and Security*, 7(5):475–481, October 1988. This paper describes a password guessing program for UNIX systems that exposes weak password choices and encourages users to make stronger selections. The paper also provides a general background in UNIX password security, a detailed description of the construction and operation of the password predictor, and a summary of the performance of the predictor. Finally, the authors propose two changes in UNIX to improve password security: the removal of world read access to the password file, and addition of audit trails for unsuccessful logins.

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[149] R. M. Needham and M. D. Schroeder. Using encryption for authentication in large networks of computers. *Communications of the ACM*, 21(12):993–999, December 1978.

[150] Evi Nemeth, Garth Snyder, and Scott Seebass. *UNIX System Administration Handbook*. Prentice Hall, Englewood Cliffs, NJ, 1989. Contains a chapter on UNIX security, including a section on passwords.

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[154] Marcus Page. Passwords are still best security method. *Government Computer News*, July 19, 1985.

are discussed. The author provides a taxonomy of pass-algorithms that are easy to memorize, easy to execute, and induce large cryptanalytic costs.

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[140] Belden Menkus. Understanding the use of passwords. *Computers and Security*, 7(2):132–136, April 1988. This article is a general primer on password security. A background on the use of passwords for authentication is provided, along with several recommendations for secure use. These recommendations include password lengths of 6-8 characters, aging passwords every 10-15 days, and penalties for password disclosure.

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[118] Stanley A. Kurzban. Easily remembered passphrases – a better approach. *ACM SIGSAC Review*, 3(2–4):10–21, Fall–Winter 1985. The paper proposes the use of passphrases for user authentication. The author claims passphrases of three or four words are more easily remembered than passwords of sufficient length to provide an equivalent combination space. The proposed scheme, Easily Remembered Passphrases (ERP), uses computer generated phrases constructed from lists of adjectives, actors, verbs, and things.

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[106] IBM Corporation. IBM transaction security system. Technical Report G52-6704, IBM Corporation, 1989.

[107] IBM Corporation. VM/SP security and integrity enhancements. Technical Report GC24-5312, IBM Corporation, 1989.

[108] IBM Corporation. AS-400 programming: Security concepts and planning. Technical Report SC21-8083, IBM Corporation, 1990.

[109] Interbank Card Association. PIN manual: A guide to the use of personal identification numbers in interchange, September 1980.

[110] Mary Jander. The naked network. *Computer Decisions*, 21(4):39–42, April 1989.

[111] David L. Jobusch and Arthur E. Oldehoeft. A survey of password mechanisms: Weaknesses and potential improvements. Part 1. *Computers and Security*, 8(7):587–603, November 1989. This paper discusses authentication and password mechanisms. The focus of the first section is user authentication; qualities of a good authentication scheme and basic methods of identifying users. The second section concentrates on password authentication schemes. Ten aspects of passwords are discussed: composition, length, lifetime, source, ownership, distribution, storage, entry, transmission, and authentication period. The final section of the paper analyzes the 4.3BSD password mechanism in terms of each of the ten aspects above.

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[94] Israel Herschberg. The hackers' comfort. *Computers and Security*, 6(2):133–138, April 1987. The author discusses the lack of security present in computing environments. According to the author, users overwhelmingly choose poor, unimaginative passwords when allowed to select their own. Users will also avoid requirements about password choice whenever possible. The lack of security of computer generated random passwords is discussed. The author recommends that passwords be screened through the use of dictionaries of poor passwords. Finally, the author criticizes the computing industry for equating user friendliness with the removal of obstacles to system use, and for the habit of adding security measures as an afterthought.

[95] Harold Joseph Highland. QETUOADGJLXVN or the selection and use of passwords for security. *Computer Compacts*, 1(1):280–281, February 1983.

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[97] Harold Joseph Highland. Random bits & bytes. *Computers and Security*, 6(2):99–110, April 1987. A user authentication card that generates a sequence of passcodes is reviewed. The passcodes change every 60 seconds, and the sequence is determined by a seed value. The user's passcode must match the passcode computed by hardware present in the host computer for access to be granted.

[98] Harold Joseph Highland. How to prevent the use of weak passwords. *The EDP Audit, Control, and Security Newsletter*, 18(9), March 1991. A password screening tool called Password Coach is reviewed. The program, developed by Charles Cresson Wood, uses multiple dictionaries and composition rules to reject weak password choices.

[99] L. J. Hoffman. *Modern Methods for Computer Security and Privacy*. Prentice-Hall, Englewood Cliffs, NJ, 1977. The author's discussion of user authentication includes the topics of password choice, length, expected safe time, one-time passwords, and question-answer authentication.

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[101] Jan Hruska and Keith Jackson. *Computer Security Solutions*. CRC Press, Boca Raton, FL, 1990. This book provides solutions to numerous security problems associated with all types of computers.

[102] Gordon Hughes. Disjointed Australian assault on hackers. *Computer Law & Practice*, 6(1):28–31, 1989.

[103] IBM Corporation. Data security controls and procedures – a philosophy for DP installations. Technical Report G320-5649, IBM Corporation, New York, 1976.

[81] John Gallant. Raid nets computers allegedly used to access NASA files. *Computerworld*, July 1984.

[82] E. Gardner, L. Samuels, and B. Render. Computer security. *The Journal of Information Systems Management*, 6(4):42, Fall 1989.

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[85] Morrie Gasser. *Building a Secure Computer System*. Van Nostrand Reinhold, New York, 1988.

[86] F. Grampp and R. Morris. UNIX operating system security. *AT&T Bell Labs Technical Journal*, 63(8):1649–1672, October 1984. This article details several areas of concern in UNIX security, passwords being one. The authors note the ease with which passwords were guessed at several locations. They also suggest several ideas that would make the password mechanism more secure.

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[88] Katherine M. Hafner. Is your computer secure? *Business Week*, August 1988.

[89] James A. Haskett. Pass-algorithms: A user validation scheme based on knowledge of secret algorithms. *Communications of the ACM*, 27(8):777–781, August 1984. The author proposes the use of pass-algorithms in addition to passwords for authentication. The paper suggests the complexity of the algorithms should vary based on factors such as login location, username, and time of day. Information on modifying the VAX/VMS operating system to use pass-algorithms is provided.

[90] F. Hayes. Is your system safe? *UNIX World*, 7(6):44, June 1990. In light of the Internet worm, this article discusses the current state of UNIX system security. The author concludes that easily guessed passwords are currently the largest problem.

[91] Colin Hebden. Secure authentication in a local area network. In *System Security: The Technical Challenge*, pages 119–128, London, October 1985. Online Publications. This paper describes the security weaknesses of local area networks. Counter-measures are discussed. In particular, the requirements for a secure authentication server are presented.

[92] Martin Hellman. DES will be totally insecure within ten years. *IEEE Spectrum*, page 32, July 1979.

[93] N. M. Herbst and C. N. Liu. Automatic signature verification based on accelerometry. *IBM Journal of Research and Development*, 16(2):245–253, May 1977.

[68] M. El-Baghdadi. The pivotal role in computer security. *Security Management*, 33(7):63, July 1989.

[69] Norman L. Enger and Paul W. Howerton. *Computer Security*. Amacom, New York, 1980.

[70] David M. England. Zodiac: Personal identification by signature. *Computer Bulletin*, 4:33–34, June 1988.

[71] Arthur Evans, Jr., William Kantrowitz, and Edwin Weiss. A user authentication scheme not requiring secrecy in the computer. *Communications of the ACM*, 17(8):437–442, August 1974. The authors propose a password system that does not require the password file to be stored secretly. They describe a scheme using one-way functions to encrypt passwords.

[72] V. Fåk. Characteristics of good one-way encryption functions for passwords – some rules for creators and evaluators. In *Computer Security: A Global Challenge*, pages 189–191, Amsterdam, September 1984. IFIP, Elsevier Science Publishing.

[73] Daniel Farmer and Eugene H. Spafford. The COPS security checker system. In *Proceedings of the Summer USENIX Conference*. The USENIX Association, June 1990.

[74] Rik Farrow. Security for superusers, or how to break the UNIX system. *UNIX/World*, 3(5):65–70, May 1986. The author describes several methods that may be used to break UNIX security and the steps that can be taken to close the holes.

[75] Rik Farrow. *UNIX System Security*. Addison Wesley, Reading, MA, 1991. The book contains several sections relating to password security, including password choice, checking the password file, and shadow passwords.

[76] David C. Feldmeier and Philip R. Karn. UNIX password security – ten years later. In *CRYPTO Proceedings*, Summer 1989.

[77] R. C. Ferreira. The smart card: A high security tool in EDP. *Philips Telecommunications Data Systems Review*, 47(3):1–19, September 1989.

[78] Ken J. Fifield. Smartcards outsmart computer crime. *Computers and Security*, 8(3):247–255, May 1989. The author advocates the use of smartcards to overcome the weaknesses of other authentication techniques such as passwords. He claims smartcards provide reliable user authentication and protection from line taps and modified system software.

[79] Philip E. Fites, Martin P. J. Kratz, and Alan F. Brebner. *Control and Security of Computer Information Systems*. Computer Science Press, Rockville, MD, 1989. Comprehensive guide to system security, including recommendations for password authentication.

[80] J. Gait. Easy entry: The password encryption problem. *Operating Systems Review*, 12(3):54–60, July 1978. The author discusses the disadvantages of unencrypted password files and the advantages of password encryption. The encryption techniques used by MULTICS and UNIX are discussed, along with improved encryption algorithms such as DES and EWK. Finally, the use of DES in hardware to provide secure communication is described.

manage a large number of passwords for privileged accounts in a distributed computing environment are discussed. The author details the development of the philosophy, policies, and methods used.

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[57] P. Cross. Computing: Beat the hackers. *Health Services Journal*, 100(5205):888–889, June 14, 1990.

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[61] Datapro Research Group. Host access control software: Technology overview. *Datapro Reports on Information Security*, pages IS52–001–121:126, July 1990.

[62] D. W. Davies and W. L. Price. *Security for Computer Networks.* John Wiley & Sons, second edition, 1989.

[63] Don Davis and Ralph Swick. Workstation services and Kerberos authentication at Project Athena. MIT Project Athena, March 3, 1989.

[64] Khosrow Dehnad. A simple way of improving the login security. *Computers and Security*, 8(7):607–611, November 1989. This paper describes a method designed to hinder trial and error guessing of passwords. Using this method, a system will reject correct passwords with a certain probability based on the number of failed login attempts. This denies the penetrator absolute knowledge of the correctness of the password.

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[29] Matt Bishop. A proactive password checker. In *Proceedings of the Seventh International Conference on Information Security*, pages 150–158, May 1991. The author discusses a technique for limiting the user's ability to pick a bad password. A UNIX implementation is described.

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A cognitive model for password selection is proposed based on semantic memory, episodic memory, and information from the environment. Various transformation and mnemonic techniques are also discussed. Finally, the authors assert that materials which would aid users in making good password choices should be readily available on the system.

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Introduction

This bibliography is the result of our examination of the current state of user authentication, with an emphasis on password authentication.

We believe that this bibliography is representative of the most important works in the area in recent years. Many of these citations include notes indicating the content of the work; however, inclusion of the citation or of additional notes does not necessarily indicate we believe the work to be more significant than other items.

We would appreciate being told of any pertinent references missing from this collection.

Acknowledgments

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User Authentication and Related Topics: An Annotated Bibliography

Eugene H. Spafford Stephen A. Weeber

Purdue Technical Report CSD–TR–91–086