

**UNITED STATES DISTRICT COURT  
NORTHERN DISTRICT OF OHIO  
CLEVELAND DIVISION**

American Civil Liberties Union of Ohio;  
Amanda Shaffer; and Michael Montgomery

Plaintiffs,

v.

Jennifer Brunner, Secretary of State of the  
State of Ohio; Cuyahoga County Board of  
Elections; Jeff Hastings, Inajo Davis Chappell,  
Robert S. Frost, and Eben O. McNair IV,  
Members of the Cuyahoga County Board of  
Elections; Cuyahoga County Board of County  
Commissioners; Peter Lawson Jones, Timothy F.  
Hagan, and Jimmy Dimora, Members of the  
Cuyahoga County Board of County  
Commissioners;

Defendants.

Case No.

**DECLARATION OF PLAINTIFFS' EXPERT MICHAEL I. SHAMOS, PH.D., J.D.**

I, Michael Ian Shamos, submit this declaration under penalty of perjury pursuant to 28 U.S.C. §1746 and depose and say as follows:

**BACKGROUND & QUALIFICATIONS**

1. My name is Michael I. Shamos. I hold the rank of Distinguished Career Professor in the School of Computer Science at Carnegie Mellon University in Pittsburgh, Pennsylvania. I am a founder and Co-Director of the Institute for eCommerce at Carnegie Mellon and direct a graduate degree program in eBusiness Technology. My résumé is attached as Exhibit 1 to this declaration.

2. I teach graduate courses at Carnegie Mellon in Electronic Commerce, including eCommerce Technology, Electronic Payment Systems, and eCommerce Law and Regulation and have done so since 1999. During the fall term in 2004 I taught a course on Electronic Voting.

3. From 1979-1987 I was the founder and president of two computer software development companies in Pittsburgh, Pennsylvania, Unilogic, Ltd. and Lexeme Corporation.

4. I am an attorney admitted to practice in Pennsylvania and before this Court and have been admitted to the Bar of the U.S. Patent and Trademark Office since 1981.

5. From 1980 through 2000 I was a statutory examiner of computerized voting systems for the Commonwealth of Pennsylvania. During that period, I participated in every electronic voting system certification examination conducted in Pennsylvania.

6. From 2005-present I have again served as statutory examiner of computerized voting systems for the Commonwealth of Pennsylvania. During that period, I have conducted approximately 21 certification examinations involving the products of seven different vendors, including the voting systems at issue in this litigation.

7. From 1987-2000 I served as statutory designee of the Attorney General of Texas for examination of voting systems pursuant to the Texas Election Code. During that period, I participated in every electronic voting system certification examination conducted in Texas.

8. I have examined voting systems for the duly constituted authorities in Delaware (1989), Massachusetts (2006), Nevada (1995) and West Virginia (1982).

9. I have been invited to speak on electronic voting at conferences and panels by the League of Women Voters, the County Commissioners Association of Pennsylvania, the Election Center, John Marshall Law School, Ohio State Moritz School of Law, University of Maryland, Pace University, University of Hong Kong, the International Workshop on Mathematics and Democracy, Rutgers University, the National Institute of Standards and Technology, American Association for the Advancement of Science, Congressional Black Caucus, Election Assistance Commission, American Enterprise Institute and the U.S. Commission on Civil Rights.

10. I testified on five occasions before committees of the U.S House of Representatives and before one committee of the U.S. Senate on electronic voting.

11. I have testified on electronic voting before the legislatures of Maryland, Pennsylvania, and Texas and the State Board of Elections of Virginia.

12. I am the sole author of three papers on electronic voting.

13. I am the author of “A Glossary of Electronic Voting,” which contains over 2000 definitions of terms relating to that subject, to be published by the National Institute of Standards and Technology in 2008.

14. I have previously testified in a number of cases concerning electronic voting. My résumé in Exhibit 1 contains a list of cases in which I have testified in the last ten years.

15. In connection with my engagement by plaintiff American Civil Liberties Union (“ACLU”), I receive \$225 per hour for my services. My compensation is not dependent on the outcome of this case.

16. I have been asked by counsel for the ACLU to draft a declaration concerning the proposed use of central count optical scanning as a voting method in Cuyahoga County.

### **OPTICAL SCANNING**

17. There are four fundamentally different voting methods used in the United States. The simplest is through hand-counted paper ballots, in which voter mark preprinted paper ballots by hand, the ballots are placed in a ballot box and at some later time are counted manually by humans. Because of the complexity of ballot used in the United States, specifically the number of races, candidates and questions to be voted on, this method of voting is impractical except in jurisdictions having small populations.

18. A second method of voting is precinct-count optical scan (PCOS). The voter marks a preprinted ballot similar to a form used on a standardized test, typically by filling in ovals or other spaces with a pen. The ballot is marked by, and can be reviewed by, the voter. The voter then personally feeds the ballot into a machine which “reads” the ballot in the presence of the voter. “Reads” is a colloquialism for “attempts to determine which spaces on the ballot have been

marked.” The machine does not “read” a ballot in the same way a human would. It ignores, for example, all text printed on the ballot and looks only at the spaces where marks are expected to be placed. Certain errors and anomalous conditions can be detected by the scanning machine at this point. For example, if the voter has selected more candidates in a race than the allowed number (overvoting), the machine can return the ballot to the voter uncounted, along with an indication that a race was overvoted. The voter can then correct the ballot or obtain a new one and try again. The machine can also detect undervoted races, that is, contests in which the voter may not have selected the maximum possible number of persons to be voted for. The machine can also detect a blank ballot – one that has no vote markings. If the ballot is not abnormal, the machine “counts” it, that is, adds one to each of its internal counters keeping track of the total number of votes cast so far for each candidate or on each issue. The ballot is then dropped into a box or bag inside the machine, where it will remain until the polls are closed.

19. A third method of voting is central-count optical scan (CCOS). In this method, the ballot is marked by the voter in the same way as for PCOS, but the ballot is neither read nor counted in the presence of the voter. If the marking occurs at a polling place, the voter simply places the ballot into a ballot box. After the polls close, the ballot box is transported to a central location (hence the term “central-count”), where, along with ballot boxes from other polling places, it will be opened and then fed into a scanner outside the presence of the voter. While this scan can also detect overvoted, undervoted and blank ballots, if such a ballot is encountered there is no way for the voter to correct it. It is typical for central-count scanners to cost a good deal more than precinct-count scanners because they can count ballots much faster. A typical precinct-count scanner may process 100 ballots an hour; a central scanner may process hundreds of ballots per minute.

20. The principal use of central-count scanning in the United States is to process absentee ballots. The voter receives an optical scan ballot in the mail (or by personally appearing at an elections office). The voter marks the ballot, often at home, and returns the voted ballot by mail. Because the voter is not present when the ballot is opened and counted, nothing additional is lost by

scanning such ballots centrally. There is no opportunity for the voter to correct the ballot, but there is never such an opportunity in absentee voting.

21. The fourth method of voting used in the United States is direct-recording electronic (DRE) voting. In this method, the voter does not mark a ballot directly, but makes choices by interacting with a computer. The computer presents the ballot selections and by using some input device such as a touchscreen, the voter can select and deselect candidates until taking the final step necessary to record a vote. Ohio requires DRE machine to produce a contemporaneous voter-verified paper audit trail (VVPAT) which is a paper representation of the voter's choices, which the voter may review and verify prior to casting a vote. The DRE machine mediates the interaction with the voter, guides the voter through the ballot and affords an opportunity for ballot review. It also prevents overvoting and is able to warn the voter of undervoting. In fact, the number of overvoted ballots cast on DRE machines is effectively zero<sup>1</sup>.

22. A ballot that is overvoted, undervoted or blank in a particular contest is said to contain a "residual vote," that is, a vote that the voter could potentially have cast but did not. While it is assumed that no one purposely overvotes, undervotes may well be voluntary. A voter who does not care about a particular race or who is not informed about the candidates may choose not to vote that race. Sometimes voters who wish to protest or just want to ensure that they remain registered cast completely blank ballots voluntarily. However, once a ballot is cast, it cannot be determined whether an undervote or blank vote is intentional. In major races, such as for President, governor or senator, it is believed that undervoting is normally a result of voter error or confusion. Sometimes the result of voter confusion can be huge. In Sarasota County, Florida in 2006, 18,412 ballots out of 142,283 cast bore no vote at all in the hotly contested U.S. House race between Christine Jennings and Vern Buchanan. No observer believes that these undervotes were intentional. It is therefore important to warn voter when they have undervoted to prevent unintentional loss of votes.

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<sup>1</sup> It is possible to overvote on a DRE in a vote-for-two office by selecting a candidate and writing in the name of the same candidate as a second choice in the same office. Such overvotes have occurred but they are extremely rare.

23. Every study of which I am aware that has compared residual vote rates in CCOS systems with those of PCOS and DRE systems finds that the residual vote rates are highest in CCOS systems. The reasons for this are clear. In PCOS and DRE systems, the ballot is counted in the voter's presence, and any anomaly can be detected and corrected. In CCOS systems, the voter is not present when the ballot is counted, so warning and correction are impossible.

24. It is possible to reduce the residual vote effect of CCOS systems by using automated ballot marking devices. I understand that Ohio does not propose to provide ballot marking devices for all in-precinct voters in Cuyahoga County. Thus the voters who do not have this advantage will not be warned of they have overvoted, undervoted, or submitted a blank ballot.

#### **HAVA REQUIREMENTS**

25. The Help America Vote Act of 2002 requires "second-chance voting," that is, a voter who has overvoted must be given a chance to correct the ballot: "(A) Except as provided in subparagraph (B), the voting system (including any lever voting system, optical scanning voting system, or direct recording electronic system) shall— ... (iii) if the voter selects votes for more than one candidate for a single office— (I) notify the voter that the voter has selected more than one candidate for a single office on the ballot; (II) notify the voter before the ballot is cast and counted of the effect of casting multiple votes for the office; and (III) provide the voter with the opportunity to correct the ballot before the ballot is cast and counted." 42 U.S.C. §14581(a)(1)(A).

26. Subparagraph (B) provides an exception: "A State or jurisdiction that uses a paper ballot voting system, a punch card voting system, or a central count voting system (including mail-in absentee ballots and mail-in ballots), may meet the requirements of subparagraph (A)(iii) by— establishing a voter education program specific to that voting system that notifies each voter of the effect of casting multiple votes for an office; and (ii) providing the voter with instructions on how to correct the ballot before it is cast and counted (including instructions on how to correct the error through the issuance of a replacement ballot if the voter was otherwise unable to change the ballot or correct any error)." 42 U.S.C. §14581(a)(1)(B).

27. Subparagraph B is a grandfather clause that permitted jurisdictions that had already adopted CCOS systems to continue using them provided that they took remedial action to instruct voters on the possibility and consequences of overvoting. It clearly deprecates CCOS systems and was not intended to provide a future exemption for jurisdictions which, as of the effective date of HAVA, were not using them.

28. Even assume that HAVA permits after-adoption of CCOS for in-precinct voters, the mandated “voter education system” must notify “each voter” of the effect of overvoting. For absentee votes this is not difficult. The mail-in ballot can be accompanied by an instruction sheet which can warn the voter and spell out the procedure for making corrections. In-precinct voters are not accustomed to reading, or even seeing, instruction sheets. They obtain a ballot, mark it, drop it in the ballot box, and leave. To be effective, the required voter education program would have to involve either (1) personal instruction by a poll worker to each voter of the consequences of overvoting; or (2) compelling each voter to read, and acknowledge understanding of, a warning sheet. Option (1) is difficult to achieve because the number of available poll workers is limited and also because of language difficulties. Poll workers would have to be provided who are able to explain the instructions in all the languages in which ballots are furnished. Option (2) is possible, but it requires the establishment of documents and procedures and training poll workers in the use of those documents and procedures.

29. HAVA also requires voting to be accessible to the disabled: “The voting system shall— (A) be accessible for individuals with disabilities, including nonvisual accessibility for the blind and visually impaired, in a manner that provides the same opportunity for access and participation (including privacy and independence) as for other voters; (B) satisfy the requirement of subparagraph (A) through the use of at least one direct recording electronic voting system or other voting system equipped for individuals with disabilities at each polling place.” 42 U.S.C. §14581(a)(3). Here there is no exception for in-precinct CCOS systems. The requirement of accessibility is absolute, and simply providing optical scan ballots at a polling place does not meet it. Cuyahoga County must provide a DRE or ballot marking device in each polling place.

30. If a DRE is provided at each polling place, then if Secretary Brunner is correct the Cuyahoga DREs are insecure<sup>2</sup>, then voters who use it will not be afforded “the same opportunity for access and participation” as voters who mark optical scan ballots.

31. If ballot marking devices are provided that are “equipped for individuals with disabilities,” the disability requirement of HAVA would be met, but voters who did not use the marking device would still be disadvantaged by not receiving the required overvote warning.

32. HAVA requires each state to provide a uniform statewide definition of what kind of mark on an optical scan ballot constitutes a vote: “ Each State shall adopt uniform and nondiscriminatory standards that define what constitutes a vote and what will be counted as a vote for each category of voting system used in the State.” 42 U.S.C. §14581(a)(6).

33. These standards differ in every state. In many cases they are counterintuitive and the standards used in different states are often contradictory. The Ohio standards are particularly difficult to locate. Therefore, even a voter who is aware that such standards exist and wants to become educated as to how to mark a ballot properly (learning which marks will and will not be counted as votes) encounters difficulty in doing so and thus may inadvertently mark a ballot improperly. This is not nearly as severe a handicap in PCOS systems because of the ability to correct the ballot. In CCOS systems it can be fatal, for the voter’s only hope that intent can be determined in a later manual recount.

## **SECURITY**

34. Cuyahoga County has apparently selected CCOS over DREs in the belief that CCOS is more secure. Even the EVEREST Report commissioned by Secretary Brunner and on which she has apparently relied, devotes an entire section (7.4) to insecurities in the M650 central count

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<sup>2</sup> I do not believe that the AccuVote TSx system used in Cuyahoga County is so flawed that its deficiencies are incapable of remediation. But the basis on which the Cuyahoga County Commissioners replaced it was Secretary Brunner’s insistence that it was too insecure for use. If so, it cannot be foisted on the disabled. If it is not insecure for use, there is no need to replace it with a CCOS system.

optical scan system<sup>3</sup>. The EVEREST Report never concludes or recommends that CCOS is any more secure than any other form of voting. DRE voting has been used in the United States since the early 1980s. Since that time, there has never been a single verified incident of tampering with a DRE system that resulted in any vote being altered. However, numerous irregularities in CCOS elections have been reported. This is recognized in the EVERST Report, which states on p. 26 that “The optical scan voting technology is often viewed as more secure because it leaves behind a hard copy record of voter choices. However, even these records are subject to the limitations of procedures. First and foremost, correcting foul play requires the recount of all physical ballots (an immense and often unpractical undertaking). If election tampering is detected at one polling place, there is a greater probability that it occurred elsewhere. Additionally, ballots returned from polling places are subject to tampering while in transit, or insecure protections could allow additional ballots to be placed in ballot boxes while at the polling place. Finally, if the election officials at the polling place itself are corrupt, there is no practical way of determining if the returned ballots are correct.”

35. In California in 2004, ballot boxes with voted optical scan ballots were found floating in San Francisco Bay three weeks after the election.

36. In Cuyahoga County’s own study in 2006<sup>4</sup>, it was found that a badly designed optical scan ballot had lines that were too close to the marking ovals, resulting in the scanner interpreting preprinted information on the ballots as votes and disenfranchising huge numbers of voters. In a CCOS system there would be no way to recover from this flaw short of a full manual recount.

37. In fact, every verified incident of tampering in U.S. elections has either involved paper ballots or lever machines, and thousands of criminal convictions have been obtained for this sort of election fraud. The fundamental premise adopted by the Secretary that CCOS is safer than DRE voting is entirely unproven and does not even make sense. In optical scan systems there is one and

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<sup>3</sup> “EVEREST: Evaluation and Validation of Election-Related Equipment, Standards and Testing. Final Report,” December 7, 2007, prepared for the Secretary of State of Ohio. The EVEREST Report also notes, as stated earlier in this declaration, that “The M650 is a batch scanner used primarily to scan mail-in (absentee) ballots.” (p. 81).

<sup>4</sup> “Cuyahoga Election Review Panel, Cuyahoga County, OH Final Report (July 20, 2006), available at [http://boccc.cuyahogacounty.us/GSC/pdf/esi\\_cuyahoga\\_final.pdf](http://boccc.cuyahogacounty.us/GSC/pdf/esi_cuyahoga_final.pdf).

only one copy of the voter's choices, namely the original paper ballot marked by the voter<sup>5</sup>. If anything happens to that ballot – if it is lost, stolen, altered, or substituted, or if additional ballots are added to the ballot box – there is absolutely no way to audit the election and there is no hope of ever determining the voters' intent. This is the reason that paper elections are so easy to corrupt – no conclusive evidence is left from which the correct totals can be obtained. By contrast, DRE systems maintain multiple copies of each ballot in distinct memory devices. Some of the memory devices are removable and are separated out at the close of polls to be sent for tabulation. But the others remain inside the voting machine. To mount an effective attack, a would-be intruder must change each copy of each encrypted ballot identically, or his fraud will be discovered (and it will be correctible). Once the removable memory has been separated from the machine, there is no practical hope of altering both it and the memories that remain in the device, and these can always be interrogated later. There is also little possibility of altering the DRE paper trail to conform to any electronic manipulation. So the conclusion that CCOS is more secure than DRE voting, or even PCOS voting, has no factual or logical basis.

#### SUMMARY

38. Cuyahoga County's premature adoption of CCOS is a step backward in voting in the United States. CCOS has uniformly higher residual vote rates than any other form of voting. CCOS is discouraged by HAVA and is permissible only under rigorous and individualized voter education standards. In-precinct CCOS is not permissible under HAVA unless devices accessible to the handicapped are provided.

39. I declare under penalty of perjury that to the best of my knowledge the foregoing is true and correct.

Executed on January 29, 2008, in Hong Kong, PRC.



Michael Ian Shamos, Ph.D., J.D.

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<sup>5</sup> Some scanning systems exist in which a digital image is taken of each ballot as it is scanned, but no such system is used, or is proposed for use, in Ohio.

# Resume of Michael Ian Shamos

## ACADEMIC

[Education](#)

[Foreign Languages](#)

[Honors](#)

[Editorships](#)

[Publications](#)

## LEGAL

[Experience](#)

[Bar Admissions](#)

[Expert Witness](#)

[Legislative Testimony](#)

[Arbitration](#)

## ELECTRONIC VOTING

[Experience](#)

[Legislative Testimony](#)

[Publications](#)

## BUSINESS

[Experience](#)

[Consulting](#)

[Directorships](#)

## PERSONAL DATA

[Contact Information](#)

## PUBLICATIONS

[Science](#)

[Digital Libraries](#)

[Electronic Voting](#)

[Billiards](#)

[In Preparation](#)

## INVITED TALKS

[Electronic Commerce](#)

[Science and Law](#)

[Electronic Voting](#)

## MISCELLANEOUS

[Personal Data](#)

## Education

**A.B.** (1968) [Princeton University \(Physics\)](#). Thesis: "An Absorber Theory of Gravitational Radiation". Advisor: [John A. Wheeler](#).

**M.A.** (1970) [Vassar College \(Physics\)](#). Thesis: "An Absorber Theory of Acoustical Radiation." Advisor: [Morton A. Tavel](#).

**M.S.** (1972) [American University](#) (Technology of Management).

**M.S.** (1973) [Yale University](#) (Computer Science).

**M.Phil.** (1974) [Yale University](#) (Computer Science).

**Ph.D.** (1978) [Yale University \(Computer Science\)](#). Thesis: "Computational Geometry". Thesis committee: [David Dobkin](#), [Martin H. Schultz](#), [Stanley C. Eisenstat](#).

**J.D.** (1981) [Duquesne University](#), *cum laude*.

## Foreign Languages

French, Russian (good reading and technical translation skills, fair conversational ability).

## Academic Experience

Distinguished Career Professor, [Institute for Software Research](#) and [Language Technologies Institute](#), [School of Computer Science](#), [Carnegie Mellon University](#) (2001- ).  
Principal Systems Scientist (1998-2001). Principal Lecturer (2002-2003). Teaching Professor (2003- ). Faculty, [Tepper School of Business](#), Carnegie Mellon University (1999-2004).

Co-Director, Carnegie Mellon [Institute for eCommerce](#) (1998- ). Vice-Chair, University Research Council (2000-2002), Director, eBusiness Technology degree program

[Contact Information](#)

(2003-).

Director, [Universal Library](#), Carnegie Mellon University (1998-).

Visiting Professor, [Department of Electrical and Electronic Engineering](#), The University of Hong Kong (2001- ).

Adjunct Faculty, Carnegie Mellon University, Department of Computer Science (1981-1998). Formerly Assistant Professor, Carnegie Mellon University, Departments of Computer Science and [Mathematics](#) (1975-81), Dept. of [Statistics](#) (1978-81).

**Recent courses taught (Carnegie Mellon):**

Algorithm Design and Analysis 15-451 (Comp. Sci.)

Intellectual Capital and its Protection 45-886 (MBA)

[Ecommerce Technology](#) 20-751 (MSEC program)[Electronic Payment Systems](#) 20-753 (MSEC program), 96-774 (MSIT program)[Ecommerce Law and Regulation](#) 46-840 (MSEC program)[Electronic Voting](#) 17-803

Ubiquitous Computing, 96-761

**Honors and Awards**Fellow, [Society of the Sigma Xi](#) (1974-83).

IBM Fellowship, Yale University (1974–75).

[SIAM](#) National Lecturer (1977–78).Distinguished Lecturer (computer science), [University of Rochester](#) (1978); [McGill University](#) (1979).

Duquesne University Law Review (1980–81).

Black &amp; White Scotch Achiever's Award (first annual, 1991, for contributions to bagpipe musicography).

Industry Service Award of the Billiard and Bowling Institute of America, 1996 (for contributions to billiard history).

Billiard Worldcup Association official referee (2001-)

## Editorships

Editor-in-Chief, [Journal of Privacy Technology](#) (2003- 2006).

Member of Editorial Board, *Electronic Commerce Research Journal* (2000- ).

Member of Editorial Board, *Pittsburgh Journal of Technology, Law and Policy* (1999- ).

Dr. Shamos has reviewed scientific papers for [Communications of the ACM](#), *Mathematical Reviews*, *IEEE Computer*, *IEEE Transactions on Computers*, [Information Processing Letters](#), [Journal of the ACM](#) and the [Journal of Computational Physics](#).

Contributing Editor, [Billiards Digest](#) magazine (1990- ).

## Legal Experience

Special Counsel, [Reed Smith LLP](#) (2000-2003), electronic commerce law.

Shareholder, [The Webb Law Firm](#) (1996-2000), intellectual property law. Associate (1990-95).

Private practice of law (1987-90), intellectual property

Associate, law firm of [Buchanan, Ingersoll, P. C.](#) (1985-87), Emerging Companies Department.

General Counsel, [Carnegie Group, Inc.](#) (1983-85), artificial intelligence company.

Private practice of law (1981-83), computer law.

## Bar Admissions

[Supreme Court of Pennsylvania](#) (1981- ).

[United States District Court for the Western District of Pennsylvania](#) (1981- ).

[United States Tax Court](#) (1982–).

[United States Court of Appeals for the Armed Forces](#)  
(1982–).

[United States Court of Appeals for the Third Circuit](#) (1982–).

[United States Supreme Court](#) (1985–).

[United States Court of Appeals for the Federal Circuit](#)  
(1985–).

### **Expert Witness**

Dr. Shamos serves as an expert witness in computer software and electronic voting cases. He has participated in the following:

*C.W. Communications, Inc. v. International Research Service, Inc.*, Civil Action No. 84-890, (W.D. Pa. 1984), aff'd. Case No. 88-3331 (3d Cir., Oct. 31, 1988). Dr. Shamos testified for plaintiff publisher as to the fame of its "Computerworld" trademark. Result: permanent injunction against defendant. Judge McCune's Memorandum and Order states. "We accept the conclusion drawn by Dr. Shamos."

*E.F. Hutton, Inc. v. Gipson* (W.D. Pa. 1985). Dr. Shamos testified for defendant-counterclaimant physician as to fraud in the inducement by a computer hardware supplier. Plaintiff had provided capital financing for the purchase. Result: defendant was awarded compensatory damages + \$250,000 punitive damages.

In re Comprehensive Business Systems, [119 B.R. 573 \(S.D. Ohio 1990\)](#). Dr. Shamos testified for a secured creditor in a bankruptcy case in which the creditor sought to obtain software still in development for which it had advanced over \$2 million in funding. Dr. Shamos opined as to the value of the incomplete software. Result: the creditor was able to purchase the software from the Trustee for \$67,500. The Court referred in its [opinion](#) to "the testimony of the eminent and impressive Dr. Shamos."

*Levinson Steel Co. v. American Software, Inc. et al.*, Civil Action No. 96-282, W.D. Pa. (1996). Dr. Shamos testified for plaintiff concerning bad faith estimates of computer processing capacity resulting in delivery of an inadequate system. Result: settlement in favor of plaintiff in an undisclosed amount. Contact: Reed Smith LLP, 435 Sixth Ave., Pittsburgh, PA 15219.

*ASE Limited v. INCO Alloys International, Inc.*, Civil Action No. 98-1266, (W.D. Pa. 1998). Dr. Shamos testified for defendant concerning breach of computer services contract by declaratory judgment plaintiff. Result: determination that defendant was free to seek services from a different vendor.

*Twentieth Century Fox Film Corp. v. iCraveTV.*, 53 U.S.P.Q. 2d 1831 (W.D. Pa. 2000). Testified for Plaintiffs concerning Internet technology used to stream video from U.S. TV stations through web sites in Canada. Result: TRO and preliminary injunction issued against defendants prohibiting continued infringement in the U.S. Contact: [Gregory Jordan, Esq.](#), [Reed Smith LLP](#), 435 Sixth Ave., Pittsburgh, PA 15219

Invited testimony before the British House of Lords, Subcommittee B of the European Union Committee, April 20, 2000. Subject: European regulation of eCommerce. View [testimony](#).

*Universal Studios, Inc. v. Reimerdes*, 111 F. Supp. 2d 294 (S. D.N.Y. 2000), aff'd 273 F.3d 429 (2d Cir. 2001). Testified for plaintiff movie studios concerning accused software for decrypting DVDs in the first case interpreting the Digital Millennium Copyright Act. Result: permanent injunction issued in favor of plaintiffs on August 17, 2000. Contact: [William Hart, Esq.](#), [Proskauer Rose LLP](#). View [testimony](#). View [opinion](#). View [appellate opinion](#).

*MercExchange, L.L.C. v. eBay, Inc. et al.*, Case No. 2:01-CV-736 (E.D. Va. 2001). Served as an expert for defendant [eBay](#) in an infringement case concerning U.S. Patent [6,202,051](#) for Internet auctions. Following Dr. Shamos' reports, Defendants obtained a summary judgment of noninfringement of the subject patent. The case continues on two other patents. Contact: [Tim Teter, Esq.](#), [Cooley](#)

*Powerquest Corp. v. Quarterdeck Corp. et al.*, Case No. 2:97-CV-0783 (D. Utah 1997). Served as an expert for plaintiff [PowerQuest](#) in an infringement case concerning U. S. Patents [5,675,769](#) and [5,706,472](#) for a method of resizing hard disk partitions. Dr. Shamos testified at the Markman hearing. Case settled when one of the defendants acquired plaintiff. Contact: [Merchant & Gould](#), Denver, CO.

*Sightsound.Com Inc. v. N2K Inc. et al.*, C.A. 98-118 (W.D. Pa. 1998). Served as an expert for defendants, including a subsidiary of Bertelsmann AG, concerning validity of U.S. Patents [5,191,573](#) and [5,966,440](#) for distribution of digital audio via telecommunications lines. Case settled. Contact: [Steven M. Hayes, Esq.](#), Parcher, Hayes & Snyder, 500 Fifth Avenue, New York, NY 10110.

*Freemarkets, Inc. v. B2eMarkets, Inc.*, C.A. 02-162-SLR (D. Del. 2002). Served as an expert witness for plaintiff concerning infringement of U.S. patents [6,216,114](#) and [6,223,167](#), concerning methods of conducting electronic auctions. Case settled two weeks after expert attended a demonstration of the accused product. Contact: [Morgan, Lewis & Bockius LLP](#), 1111 Pennsylvania Ave. N.W., Washington, DC 20004.

*Lifecast.com, Inc. v. ClubCorp, Inc.*, AAA Case No. 71Y1170076301 (Dallas, TX). Served as an expert witness for respondent in a case alleging copyright infringement of Internet websites. Testified at arbitration. Result: Complainant's claims denied; award for respondent on counterclaims and for attorney's fees. Contact: [Bill Whitehill, Esq.](#), [Gardere Wynne Sewell LLP](#), 1601 Elm St., Dallas, TX 75201.

*IP Innovation LLC v. Thomson Learning, Inc. et al.*, Case H-02-2031 (S.D. Tex. 2002). Served as a expert for defendant The Princeton Review, Inc. concerning alleged infringement of U.S. Patent [4,877,404](#) relating to online delivery of educational courses. Summary judgment of non-infringement obtained for defendant after favorable Markman proceeding. Contact: [Peter Vogel, Esq.](#), [Gardere Wynne Sewell LLP](#), 1601 Elm St., Dallas, TX 75201.

*Starpay.com LLC et al. v. Visa International Service Association et al.*, Case 3-03-CV-976-L (N.D. Tex. 2003). Serving as an expert for defendant Visa concerning alleged infringement of U.S. Patent [5,903,878](#) relating to online authentication of credit card customers. Dr. Shamos provided the court with a Markman tutorial on Oct. 22, 2004. Status: pending. View Markman order. Contact: [Stanley Young, Esq.](#), [Heller Ehrman, LLP](#), 275 Middlefield Road, Menlo Park, CA 94025.

*Safeclick LLC v. Visa International Service Association et al.*, Case C-03-5865 (N.D. Cal. 2003). Served as an expert for defendant Visa concerning alleged infringement of U.S. Patent [5,793,028](#) relating to online authentication of credit card customers. Summary judgment of noninfringement granted for Visa based on expert reports, affirmed after appeal to the Federal Circuit. Contact: [Stanley Young, Esq.](#), [Heller Ehrman, LLP](#), 275 Middlefield Road, Menlo Park, CA 94025.

*Wells Fargo Bank Minnesota, NA et al. v. UBS Warburg Real Estate Securities, Inc.*, Case 02-2849 (192d Judicial District, Dallas Cty., Tex, 2002) and *LaSalle Bank, NA et al. v. UBS Warburg Real Estate Securities, Inc.*, Case 02-2899-G (134th Judicial District, Dallas Cty., Tex, 2002). Served as an expert for defendant UBS Warburg in an electronic discovery matter involving a case of first impression regarding Texas Discovery Rule 196.4 allocating costs of discovery of electronic records. Status: pending. Contact: [Dawn Estes, Esq.](#), [Gardere Wynne Sewell LLP](#), 1601 Elm St., Dallas, TX 75201.

*American Association of People with Disabilities et al. v. Shelley et al.*, Case No. CV04-1526 FMC (PJWx) (C. D. Calif., 2004). Served as an expert for plaintiff AAPD, which has brought a claim against the California Secretary of State that requiring DRE voting machines to be equipped with audit trails violates the rights of disabled persons. Plaintiffs' application for TRO and preliminary injunction denied. Contact: [John McDermott, Esq.](#), [Howrey Simon Arnold & White](#), 550 South Hope St., Suite 1100, Los Angeles, CA 90071.

*Paul Ware v. Target Corp.*, CA 4:03-CV-0243-HLM (N.D. Ga., 2003). Served as an expert for defendant Target Corp., a

large retailer, in a case involving U.S. patent [4,707,492](#), claiming a method of conducting credit card sales. Case settled during Markman preparations. Contact: [Thomas Burke, Esq.](#), [Ropes & Gray LLP](#), 1211 Ave. of the Americas, New York, NY 10036.

*Viad Corp., v. C. Alan Cordial et al.*, No. 03-1408 (W.D. Pa., filed 2003). Served as an expert for defendants in an action alleging misappropriation of trade secrets relating to software for automating certain aspects of the exhibit booth and trade show industries. Status: case settled immediately before trial, after plaintiff's unsuccessful Daubert challenge of Dr. Shamos. Contact: [Barbara Scheib, Esq.](#), [Cohen & Grigsby, P.C.](#), 11 Stanwix Street, Pittsburgh, PA 15222.

*Schade et al. v. Maryland State Bd. of Elections et al.*, Case No. C0497297 (Cir. Ct. Anne Arundel Cty. Md., 2004). Serving as an expert for defendants in a case challenging the decision of the Board of Elections not to decertify Diebold AccuVote system. Result: Plaintiff's motion for preliminary injunction denied, upheld on appeal. Judge Manck's [opinion](#) cites Dr. Shamos' testimony as follows: "the court finds Dr. Shamos, Defendants' expert, to be the true voice of reason and the most credible expert in this matter." The denial of preliminary injunction was upheld by the Maryland Court of Appeals, which commented extensively on Dr. Shamos' testimony in its [opinion](#). Remainder of case is pending. Contact: [Michael Berman, Esq.](#), Deputy Attorney General, 200 St. Paul Place, Baltimore, MD 21202-2021.

*Wexler et al. v. Lepore et al.*, Case No. 04-80216 (CIV-COHN) (S.D. Fla. 2004) . Served as an expert for defendants, various Florida election supervisors against claim by U.S. Congressman Robert Wexler that use of DRE voting machines without paper audit trails violates the equal protection clause of the U.S. Constitution. Dr. Shamos testified on Oct. 19, 2004. The trial judge rendered [judgment](#) in favor of defendants on Oct. 25. Contact: [Jason Vail, Esq.](#), Assistant Attorney General, Department of Legal Affairs, The Capitol, Tallahassee, FL 32399-1050. [Opinion](#).

*Siemens Information and Communication Networks, Inc. v. Inter-Commercial Business Systems, Inc.*, Civil Action 3-03CV2171-L (N.D. Tex. 2004). Served as an expert for defendant against claim of copyright infringement based on

Case 1:08-cv-00145-KMO Document 8-5 Filed 01/28/2008 Page 19 of 34  
reverse-engineered firmware resident in telephone switching systems. Status: case settled shortly after the submission of Dr. Shamos's rebuttal report on non-infringement. Contact: [Bill Whitehill, Esq.](#), [Gardere Wynne Sewell LLP](#), 1601 Elm St., Dallas, TX 75201.

*Soverain Software LLC v. Amazon.com, Inc.*, C.A. No. 6:04-CV-14 (E.D. Tex. 2004). Served as an expert for plaintiff regarding asserted patents [5,708,780](#), [5,715,314](#) and [5,909,492](#), relating to the shopping cart paradigm of electronic commerce. Status: settled in Sept. 2005 with Amazon paying \$40 million to Soverain and taking a license under the patents in suit. Contact: [Thomas L. Giannetti, Esq.](#), [Jones Day](#), 222 E. 41st St., New York, NY 10017.

*CollegeNET, Inc. v. The Princeton Review, Inc.*, Case '051205KI (D. Ore. 2005). Serving as a expert for defendant The Princeton Review, Inc. concerning alleged infringement of U.S. Patent [6,460,042](#) relating to online delivery of educational courses. Case is pending. Contact: [Peter Vogel, Esq.](#), [Gardere Wynne Sewell LLP](#), 1601 Elm St., Dallas, TX 75201.

*CombineNet, Inc. v. Verticalnet, Inc.*, GD 05-018911 (Ct. Common Pleas, Allegheny Cty., PA). Served as an expert for plaintiff in an action for trade secret misappropriation relating to a system for conducting electronic auctions. Plaintiff won in arbitration. Contact: [Mark Knedeisen, Esq.](#), [Kirkpatrick & Lockhart Preston Gates Ellis LLP](#), 535 Smithfield Street, Pittsburgh, PA 15222-2312.

*RealSource, Inc. v. Best Buy Co., Inc. et al.*, No. A04-CA-771-LY (W.D. Tex.). Serving as an expert for defendant Lowe's Companies, Inc., against a claim of infringement of U.S. patent [5,732,136](#) relating to validation of point-of-sale debit card transactions. Provided a tutorial to the Court during Markman proceedings concerning debit card technology. Case is pending. Contact: [Michael S. Connor, Esq.](#), [Alston & Bird LLP](#), Bank of America Plaza, 101 South Tryon St, Suite 4000, Charlotte, NC 28280-4000.

*DE Technologies, Inc. v. Dell, Inc. et al.*, No. 7:04-CV-00628 (W.D. Va.). Serving as an expert for plaintiff DE Technologies, Inc., asserting a claim of infringement of U.S. patents [6,460,020](#) and [6,845,364](#), relating to a system for

Case 1:08-cv-00145-KMO Document 8-5 Filed 01/28/2008 Page 20 of 34  
implementing international sales transactions. Case settled after and adverse summary judgment. However, the Court used Dr. Shamos' testimony in its [opinion](#). Contact: [David Marder, Esq., Robins Kaplan Miller & Ciresi LLP](#), 800 Boylston Street, 25th Floor, Boston, MA 02199.

*Eaton Power Quality Corp. v. J.T. Packard & Associates*, No. 05 C 3545 (N.D. Ill. 2005). Served as expert for plaintiff in a claim of software copyright infringement involving a system for configuring industrial uninterruptible power supplies. Case settled in early 2007. Contact: [Keith Schoeneberger, Esq., LeBoeuf, Lamb, Greene & MacRae LLP](#), Suite 1175, 180 North Stetson Ave., Chicago, IL 60601-6783.

*Taylor et al. v. Onorato et al.*, CA 06-481 (W.D. Pa 2006). Served as an expert for Commonwealth of Pennsylvania defendants in an action seeking to enjoin the use of electronic voting machines in Allegheny County, PA. Dr. Shamos testified at length in a preliminary injunction hearing held April 25-27, 2006. The injunction was denied on April 28. Suit was subsequently dropped by plaintiffs. Contact: [Mark Aronchick, Esq., Hangley Aronchick Segal & Pudlin](#), One Logan Square, 18th & Cherry Streets, 27th Floor, Philadelphia, PA 19103.

*FedEx Ground Package System, Inc. v. Applications International Corp.*, CA No. 03-1512 (W.D. Pa.). Serving as an expert for defendant counterclaiming for copyright infringement and trade secret misappropriation relating to software for maintaining occupational health and safety records. Case is pending. Contact: [Ronald Hicks, Esq., Meyer, Unkovic & Scott LLP](#), 1300 Oliver Bldg., Pittsburgh, PA 15222.

*NetMoneyIN, Inc. v. Verisign, Inc. et al.*, Cv-01-441-TUC-RCC (D. Ariz.). Served as an expert for defendants Bank of America Merchant Services, Inc. and Wells Fargo Bank, N.A., who are accused of infringing claim 23 of U.S. patent [5,822,737](#), relating to an electronic payment system. Wells Fargo and Bank of America have settled. Contact: [Robert Smith, Esq., Kirkpatrick & Lockhart Preston Gates Ellis LLP](#), State Street Financial Center, One Lincoln Street, Boston, Massachusetts 02111-2950.

*Contois Music Technology, LLC v. Apple Computer, Inc.*,

Case 1:08-cv-00145-KMO Document 8-5 Filed 01/28/2008 Page 21 of 34  
2:05-CV-163 (D. Vermont, filed Feb. 13, 2006). Served as an expert for plaintiff in an action alleging that the Apple iTunes software infringed U.S. patent [5,864,868](#), relating to a method for selecting music from an electronic catalog. Case settled after a favorable Markman order. Contact: [John Rabena, Esq.](#), [Sughrue Mion, PLLC](#), 2100 Pennsylvania Avenue, NW, Suite 800, Washington, DC 20037-3213.

*Banfield et al. v. Cortes*, 442 MD 2006 (PA Cmwlth. Ct.). Serving as an expert for defendant Secretary of the Commonwealth of Pennsylvania in an action to compel the decertification of all electronic voting machines in Pennsylvania. Case is pending. [Alan Promer, Esq.](#), [Hangley Aronchick Segal & Pudlin](#), One Logan Square, 18th & Cherry Streets, 27th Floor, Philadelphia, PA 19103.

*Remote Inventory Systems, Inc. v. WESCO Distribution, Inc.*, AAA Case No. 55 171 00493 05 (Pittsburgh, PA). Serving as an expert for respondent in a case alleging misappropriation of trade secrets in a computerized inventory system. Case is pending. Contact: [Kirsten Rydstrom, Esq.](#), [Reed Smith LLP](#), 435 Sixth Ave., Pittsburgh, PA 15219.

*SyncSort, Inc. v. Innovative Routines International, Inc.*, Civil Action No. 04-3623 (WHW) (D. New Jersey). Serving as an expert witness for defendant in an action alleging misappropriation of trade secrets embodied in plaintiff's Unix sorting software. Case is pending. Contact: [David R. Fine, Esq.](#), [Kirkpatrick & Lockhart Preston Gates Ellis LLP](#), 17 N. Second Street, 18th Floor, Harrisburg, PA 17101-1507.

*Digital Impact, Inc. v. Bigfoot Interactive, Inc.*, Civil Action C05 00636 (CW) (N.D. Cal.). Serving as an expert witness for defendant in an action alleging infringement of U.S. Patent [6,449,634](#), relating to determining which file formats can be processed by an email client. Case is pending. Contact: [Arthur Dresner, Esq.](#), [Reed Smith LLP](#), 599 Lexington Avenue, New York, NY 10022.

*Prism Technologies LLC v. Verisign, Inc. et al.*, CA 05-214-JJF (D. Del.). Serving as an expert for plaintiff in an action alleging infringement of U.S. Patent [6,516,416](#), relating to use of a hardware key for authentication over networks. Case is pending. Contact: [Robins Kaplan Miller & Ciresi LLP](#).

*AdvanceMe, Inc. v. Rapidpay LLC et al.*, Civil Action 6:05-cv-424 (E.D. Tex., Tyler Division). Serving as an expert witness for plaintiff in an action alleging infringement of U.S. Patent [6,941,281](#), relating to an automated payment system for dividing credit card proceeds between a merchant and another party. Testified at a bench trial in July 2007 before Judge Davis, who held the patent invalid for obviousness. Case is on appeal to the Federal Circuit. Contact: [Ronald S. Lemieux, Esq.](#), [Paul, Hastings, Janofsky & Walker LLP](#), Five Palo Alto Sq., Palo Alto, CA 94306.

*IBM Corp. v. Amazon.com, Inc.*, CA 9:06-CV-242-RHC (E.D. Tex., Lufkin Div.) and *IBM Corp. v. Amazon.com, Inc.*, CA 6:06-CV-452-LED (E.D. Tex., Marshall Div.). Served as an expert for IBM in related actions alleging infringement of U.S. Patents [5,319,542](#), [5,442,771](#), [5,446,891](#), [5,796,967](#) and 7,072,849, all concerning methods of conducting electronic transactions, and a counterclaim for infringement of U.S. Patent [5,826,258](#), concerning a method for querying semistructured data. Case settled early in discovery when the parties cross-licensed each other's patents. Contact: [Mark Ziegelbein, Esq.](#), [Jones Day](#), 2727 North Harwood Street, Dallas, TX 75201-1515.

*The MathWorks, Inc. v. COMSOL AB et al.*, CA 6:06-CV-334 (E.D. Tex., Tyler Division). Serving as an expert for plaintiff The MathWorks, providers of the mathematical software system MATLAB, in an action alleging infringement of U.S. Patents [7,051,338](#) and [7,181,745](#) concerning methods for invoking object methods from external environments. Case is pending. Contact: [Krista Schwartz, Esq.](#), [Jones Day](#), 77 W. Wacker Dr., Chicago, IL 60601-1692.

*Avante Int'l. Technology Corp. v. Diebold Election Systems et al.*, Case 4:06-CV-0978 (E.D. Mo., Eastern Division). Serving as an expert for defendant Sequoia Voting Systems in an action alleging infringement of U.S. Patents [6,892,944](#), [7,036,730](#) and [7,077,313](#) concerning electronic voting technology. Case is pending. Contact: [Peter Ewald, Esq.](#), [Oliff & Berridge, PLC](#), 277 South Washington Street, Suite 500, Alexandria, VA 22314.

## **Legislative Testimony**

Case 1:08-cv-00145-KMO Document 8-5 Filed 01/28/2008 Page 23 of 34  
Testimony before the Texas Legislature concerning electronic voting, Austin, Texas, 1987. Result: passage of the Texas Electronic Voting Law.

Invited [testimony](#) before the British House of Lords, Subcommittee B of the European Union Committee, April 20, 2000. Subject: European regulation of eCommerce.

[Testimony](#) before the Pennsylvania Legislature State Government Committee concerning electronic voting, Philadelphia, March 10, 2004.

[Testimony](#) before the United States Commission on Civil Rights concerning electronic voting, Washington, DC, April 9, 2004.

[Testimony](#) before the U.S. House of Representatives Committee on Science concerning voting system certification, Washington, DC, June 24, 2004.

[Testimony](#) before the U.S. House of Representatives Committee on House Administration concerning voting system security, Washington, DC, July 7, 2004.

[Testimony](#) before the U.S. House of Representatives Committee on Government Reform concerning electronic voting technology, Washington, DC, July 20, 2004.

Testimony on DREs and paper trails before the Virginia Legislature Study Commission on Voting System Certification and Security, Richmond, VA, August 16, 2004.

[Testimony](#) before the Election Assistance Commission, Technical Guidelines Development Committee, Subcommittee on Computer Security and Transparency, Gaithersburg, MD, Sept. 20, 2004.

[Testimony](#) before the House Ways and Means Committee of the Maryland General Assembly on voting machine paper trails, Annapolis, MD, December 7, 2004.

[Testimony](#) before the U.S. House of Representatives Committee on House Administration concerning paper trails, Washington, DC, September 28, 2006.

[Testimony](#) before the U.S. Election Assistance Commission concerning the Voting System Testing and Certification Program, Washington, DC, October 26, 2006.

Testimony before the Georgia State Board of Elections, Powder Springs, GA, December 21, 2007.

Testimony before the Maryland House of Delegates Ways and Means Committee, Annapolis, MD, January 18, 2007.

[Testimony](#) before the U.S. Senate Committee on Rules and Administration on the Ballot Integrity Act of 2007, Washington, DC, July 25, 2007.

### **Arbitration**

Dr. Shamos has served as an arbitrator in computer-related disputes for the American Arbitration Association.

### **Electronic Voting**

Dr. Shamos has served as an examiner of electronic voting systems and consultant on electronic voting.

Consultant to the Pennsylvania Secretary of the Commonwealth (2004- ).

Member, Sarasota Source Code Audit Task Force, Florida Secretary of State (2006-2007)

Consultant to the Massachusetts Secretary of the Commonwealth (2006).

Project SERVE Security Peer Review Group (2003).

Attorney General's Designee for electronic voting examinations, State of Texas (1987-2000).

Attorney for Counsel to the Secretary of the Commonwealth, Commonwealth of Pennsylvania. (1998-2000); Statutory Examiner for electronic voting, Commonwealth of Pennsylvania (1980-1996).

Consultant to Montgomery County, Pennsylvania (1996).

Consultant to the Delaware Legislature (1989).

## **Business Experience**

President, Unus, Inc., database publishing software (formerly Unilogic, Ltd.) (1990-1992)

President, Lexeme Corporation (1984-87), software language translation products.

Managing Partner, Shamos and Tchen (1978-82), computer consulting firm.

Supervisory Programmer, National Cancer Institute (1970-72), while a commissioned officer in the United States Public Health Service (O-3).

Associate Engineer, IBM Corporation (1968-70), design of manufacturing information systems.

## **Consulting**

[Morgan Stanley Dean Witter](#) (2000-2002 ). Contact: [Stephanie Homes](#).

[McKinsey & Co.](#) (1999-2001). Contact: [Will Draper](#) (BTO Stamford)

[Bell Atlantic Corporation](#) (1999-). Contact: [John Martin](#).

[LG-CNS](#), South Korea (2002-). Project to automate the Korean court system.

## **Directorships**

Unilogic, Ltd. (1979–87) (later Unus, Inc. d/b/a Cygnet Publishing Technologies, 1987- ). Database publishing software.

The Billiard Archive (1983– ). Historical nonprofit foundation.

Insurance Technology Corporation (1992–1995). IT  
consulting for the insurance industry.

## **Personal Data**

Date of birth: April 21, 1947.

Married to Julie Shamos (formerly Julie Van Allen), August  
12, 1973.

Children: Josselyn (born May 20, 1982), Alexander (born  
August 3, 1984).

Military Status: Veteran (Commissioned Officer, [U.S. Public  
Health Service](#), 1970-72).

Health: excellent

## **Contact Information**

### Office Address:

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Carnegie Mellon University  
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### Home Address:

605 Devonshire Street  
Pittsburgh, PA 15213-2904  
Home Telephone: 412-681-8398  
Home Fax: 412-681-8916

## **Publications**

### **SCIENCE**

#### **Books**

1. [Computational Geometry: An Introduction](#), with F. P. Preparata.  
Springer-Verlag (1985, revised ed., 1991), 390 pp. ISBN 0387961313.

According to [Citeseer](#), this is the 28th most frequently cited work in computer science.

2. [Vyichislitel'naya Geometria: Vyedyeniye](#). Russian translation of "Computational Geometry: An Introduction." Moscow: Mir Publishers (1989). ISBN 5030010416.
3. *Keisan kikagaku nyumon*. Japanese translated by T. Asano and T. Asano of *Computational Geometry: An Introduction*, with F. P. Preparata. Soken Shuppan (Jul. 1992). ISBN4795263213.
4. [Handbook of Academic Titles](#). 198 pp. (Nov. 2002). An encyclopedia of various academic designations used at over 1000 colleges and universities in the United States.
5. *Geometria obliczeniowa. Wprowadzenie*. Polish translation of "Computational Geometry: An Introduction." Warsaw: Helion (2003) 392 pp. ISBN 83-7361-098-7.

#### Articles

1. "On the Piezoelectric Effect in Bone," with M. H. Shamos and L. S. Lavine. *Nature* **197**:81 (1963).
2. "An Absorber Theory of Acoustic Radiation," with M. A. Tavel. *Journal of the Acoustical Society of America* **54**:46–49 (1973).
3. "Problems in Computational Geometry." Unpublished book manuscript (1974, revised 1977). Distributed in photocopy.
4. "Geometric Complexity." *Proceedings of the Seventh Annual ACM Symposium on Automata and Theory of Computation* (May 1975) 224–233.
5. "Closest-point Problems," with D. J. Hoey. *Proceedings of the Sixteenth IEEE Symposium on Foundations of Computer Science* (Oct. 1975) 151–162.
6. "Divide and Conquer in Multidimensional Space," with J. L. Bentley. *Proceedings of the Eighth Annual ACM Symposium on Automata and Theory of Computing* (May 1976) 220–230.
7. "Geometric Intersection Problems," with D. J. Hoey. *Proceedings of the Seventeenth Annual IEEE Symposium on Foundations of Computer Science* (Oct. 1976) 208–215.

8. "Lower Bounds from Complex Function Theory," with G. Yuval. *Proceedings of the Seventeenth Annual IEEE Symposium on Foundations of Computer Science* (Oct. 1976) 268–273.
9. "Geometry and Statistics: Problems at the Interface." In *Algorithms and Complexity: New Directions and Recent Results*, J. F. Traub, ed., Academic Press (1976) 251–280.
10. "Divide and Conquer for Linear Expected Time," with J. L. Bentley. *Information Processing Letters* 7 (1977) 87–91.
11. "A Problem in Multivariate Statistics: Algorithm, Data Structure, and Applications," with J. L. Bentley. *Proceedings of the Fifteenth Allerton Conference on Communications, Control and Computers* (Sep. 1977) 193–201.
12. "Optimal Algorithms for Structuring Geographic Data," with J. L. Bentley. *Proceedings of the Harvard Conference on Topological Data Structures for Geographic Information Systems* (Oct. 1977) 43–51.
13. "Computational Geometry." Ph.D. Thesis, Yale University (1978). [University Microfilms](#), Ann Arbor, MI.
14. "On Time and Space," with A. R. Meyer. In *Perspectives on Computer Science*, A. K. Jones, ed. Academic Press (1978).
15. *Combinatorics on Graphs I: Graph Polynomials*. Unpublished book manuscript (1978).
16. "Robust Picture Processing Operators and Their Implementation as Circuits." *Proceedings of the Fall 1978 Workshop on Image Processing*, Carnegie Mellon University (1978).
17. "A practical system for source language translation," with T. R. Kueny and P. L. Lehman. *Proceedings of the National Conf. on Software Reuseability and Maintainability*, pp. B-1 – B-12, Washington, DC (Sep. 1986).
18. "The Early Years of Computational Geometry – A Personal Memoir." *Advances in Discrete and Computational Geometry* (B. Chazelle, J. E. Goodman, and R. Pollack, eds.), *Contemporary Mathematics*, Amer. Math. Soc., Providence (1998).

## DIGITAL LIBRARIES

1. "Machines as readers: a solution to the copyright problem." J. Zhejiang Univ. Science 6A, 11, pp. 1179-1187 (Nov. 2005).

### Reports

1. "Japanese Digital Information Policy, Intellectual Property and Economics," in "[Digital Information Organization in Japan](#)," International Technology Research Institute (1998).

## ELECTRONIC VOTING

### Articles

1. "Voting System Certification — An Examiner's View." Invited paper presented at the Election Center Conference, Reno, Nevada (Sep. 1989).
2. "[Electronic Voting — Evaluating the Threat](#)." Proc. Third ACM Conf. on Computers, Freedom & Privacy, San Francisco, CA (Mar. 1993).
3. "[Paper v. Electronic Voting Records — An Assessment](#)." Proc. 14th ACM Conf. on Computers, Freedom & Privacy, Berkeley, CA (Apr. 2004).
4. "[Evaluation of Voting Systems](#)," with P.L. Vora, B. Adida, R. Bucholz, D. Chaum, D. Dill, D. Jefferson, D. Jones, W. Lattin, A. Rubin and M. Young, Commun. ACM 47(11):144 (2004).
5. "[Voting as an Engineering Problem](#)." *The Bridge* (publication of the National Academy of Engineering), Summer 2007, pp. 35-39.

## BILLIARDS

### Books

1. [Pool](#). New York: Mallard Press division of Bantam-Doubleday-Dell Promotional Book Company (Aug. 1991). 128 pp. ISBN 0-7924-5310-7.
2. [Le billard et le billard américain](#). Paris: Minerva, 1992, reprinted 1997. 128 pp. Translation by Jean-Yves Prate of the author's American book, *Pool*. ISBN 2-8307-0160-7 (1992), 2-8814-3135-6 (1997).
3. [The Illustrated Encyclopedia of Billiards](#). New York: Lyons & Burford (1993). 310 pp. ISBN 1-55821-219-1.

4. [\*Pool Snooker Carambola\*](#). Padua: Facto Edizioni (1993). 128 pp. Italian translation of *Pool*. Translated by Elisabetta Bezzon. ISBN 88-85860-20-6. The only English-language billiard book ever published in Italian.
5. [\*Pool\*](#). New York: Friedman/Fairfax (Jun. 1994). 128 pp. ISBN 1-56799-061-4. Paperback edition of the author's 1991 [\*Pool\*](#).
6. [\*Shooting Pool: The People, the Passion, the Pulse of the Game\*](#), with photographs by George Bennett. New York: [Artisan](#) (Jun. 1998). 144 pp. ISBN 1-885183-95-X. A Book-of-the-Month Club bonus selection (Fall, 1998).
7. [\*Setting the Stage for Fifty Years\*](#). Coralville, IA: [Billiard Congress of America](#) (Jun. 1998). 88 pp. A history of the Billiard Congress of America.
8. [\*The New Illustrated Encyclopedia of Billiards\*](#). New York: [Lyons Press](#) (1999). 320 pp. ISBN 1-55821-797-5. An expanded and revised edition of [\*The Illustrated Encyclopedia of Billiards\*](#).
9. [\*The Complete Book of Billiards\*](#). New York: [Gramercy Books](#) (2000). 306 pp. ISBN 0-517-20869-5. Reissue of author's 1993 [\*The Illustrated Encyclopedia of Billiards\*](#).

## In Preparation

## SCIENCE

### Books

1. *A Catalog of the Real Numbers*. A list, patterned after Sloane & Plouffe, [The Encyclopedia of Integer Sequences](#), Academic Press (1995). Over 8000 interesting real numbers arranging in lexical order by decimal expansion, with accompanying formulas.
2. *Handbook of Academic Titles*.

### Articles

1. *Overcounting Functions*. A systematic method of transforming certain multiple summations into single summations, with new number-theoretic results.
2. *Property Enumerators and a Partial Sum Theorem*. A new result allowing rapid symbolic evaluation of certain types of double summations.

## **LAW**

### **Books**

1. *A Dictionary of American Intellectual Property.*
2. *Electronic Voting Glossary.* To be published by NIST.

### **Invited Talks**

## **ELECTRONIC COMMERCE**

"The U.S., Korea and the Internet Bubble." Korea International Trade Association (Seoul, July 2003).

"Electronic Judiciary Services in the United States." Address at the Supreme Court of Korea (Dec. 2004).

"eGovernment in the United States." Public address at the University of Hong Kong (Feb. 2005).

"Global SCM as a Cross-Border eCommerce Model," Korea International Trade Association, Seoul, Korea (Mar. 2007).

## **SCIENCE AND LAW**

"Digital Property in the 21st Century." Keynote address for the Spring Meeting of the American Intellectual Property Law Association, Pittsburgh, PA (May 2000). View [slides](#).

"Who Owns This Algorithm?" Carnegie Mellon University (Nov 1991); Microelectronics and Computer Corporation (Jan. 1992); Univ. of Texas at Austin (Jan. 1992); UCLA (Feb. 1992).

"New Computer Technology and Its Application to Worker's Compensation." Forum IV, Newport Beach, CA (Feb. 1992).

"The Office of the Future, If There Is One." 1994 IAIABC Conf., Pittsburgh, PA (Sep. 1994).

"The Fringes of Infringement." University of Texas, Austin, TX (Sep. 1995).

"The Arts and the Internet." Allegheny County Bar Association Continuing Legal Education course (June 26, 1996).

"The Universal Information Resource." Inventing the Future, Symposium in Honor of Raj Reddy's 60<sup>th</sup> Birthday, Carnegie Mellon University, Pittsburgh, PA (May 1998).

"The Universal Library." University of Texas at Austin (Sep. 1998)

"The Universal Library and Its Role in Scientific Information." Keynote address to the RNA Society symposium on Emerging Sources of RNA Information, Arlington, VA (Dec. 8, 1998).

"Digital Property in the 21st Century." Luncheon address to the American Intellectual Property Law Association, Pittsburgh, PA (May. 2000).

"The Future of eCommerce." Address to the Association for Corporate Growth, Pittsburgh, PA (Dec. 2001).

"Copyright Protection and Distance Learning." Hong Kong Intellectual Property Office (Feb. 2002).

"Surprises in Experimental Mathematics." Carnegie Mellon University Mathematics Seminar (Feb. 2002).

"The Universal Dictionary." Address at International Institute of Information Technologies (IIIT), Hyderabad, India (Jan. 2003).

"The Million Book Projects." Public address at the University of Hong Kong (Jan. 2003).

"Mathematics and the Privacy Laws." ALADDIN Workshop on Privacy in D.A.T.A., Pittsburgh, PA (Mar. 2003).

"Machines as readers: a solution to the copyright problem." 1st Int'l Conf. on Universal Digital Library, Hangzhou, China (Nov. 2005).

"University Technology Transfer: How to Fix It." Asia Conference on Technology Transfer (ACTT) 2006, Seoul, S. Korea (Mar. 2006).

"How Big a Problem is Copyright"? USAIN Conference, Cornell University, Ithaca, NY (Oct. 2006).

"Digital Ownership." 2d Intl. Conf. on Universal Digital Library, Alexandria, Egypt (Nov. 2006).

## **ELECTRONIC VOTING**

"Voting System Certification — An Examiner's View." Election Center Conference, Reno, Nevada (Sep. 1989).

"Electronic Voting — Evaluating the Threat." Third Conf. on Computers, Freedom and Privacy, San Francisco, CA (Mar. 1993).

"What's Happening in Florida?" Carnegie Mellon University (Nov. 2001)."

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