RONALD FAGIN

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Education

Ph.D. in Mathematics, University of California at Berkeley, 1973
Thesis: *Contributions to the Model Theory of Finite Structures*
Advisor: Prof. Robert L. Vaught
National Science Foundation Graduate Fellowship 1967-72
Research Assistantship 1972-73
Passed Ph.D. Qualifying Exams "With Distinction" (top 5%).

Bachelor's Degree in Mathematics, Dartmouth College, 1967
Held National Merit Scholarship, 1963-67
Elected to Phi Beta Kappa, 1966
Graduated Summa cum laude
Graduated With Highest Distinction in Mathematics.

Professional Experience

IBM Fellow, 2012–present

IBM Research – Almaden (formerly IBM Research Laboratory), San Jose, California, 1975–present

- Founder, and first manager of, the Theory Grouop, 1979
- Manager, Foundations of Computer Science, 1979–2012
- Acting Senior Manager, Mathematics and Related Computer Science, 1995
- Acting Senior Manager, Principles and Methodologies, 2004

Research Fellow, IBM Haifa Research Laboratory, 1996-1997 (and was visitor to IBM Haifa during summers of 1998, 1999, and 2000)

Visiting Professor, Pontifícia Universidade Católica do Rio de Janeiro, 1981

IBM Watson Research Center, Yorktown Heights, N.Y., 1973–1975

- Served as Technical Assistant to Director of Computer Science Dept.

Computer programmer for Kiewit Computation Center, Dartmouth College, Hanover, N.H., 1967

Research Assistant to John G. Kemeny, Chairman of Mathematics Dept., Dartmouth College, Hanover, N.H., 1965–1967

Honors

- Named Fellow of Asia-Pacific Artificial Intelligence Association, 2022
- Named to Hall of Fame of Northwest Clssen High School in Oklahoma City, Oklahoma, 2021
- Received jontly with Phokion Kolaitis, Renée Miller, Lucian Popa andWang-Chiew Tan) the 2020 Alonzo Church Award for Outstanding Contributions to Logic andComputation, for laying logical foundations for data exchange.
- Elected to the U.S. Natinoal Academy of Sciences, 2020
- Had research on "A logic for reasoning about probabilities" named as IBM Research Division Accomplishment for 2018, and awarded an IBM Outstanding Technical Achievement Award for this work in 2019.
- Had research on 'Foundations for inverses of schema mappings and applications to schema evolution management" named as IBM Research Division Accomplishment for 2018, and awarded an IBM Outstanding Technical Achievement Award for this work in 2019.
- Had research on "AI with (expert) human-in-the-loops" named as IBM Research Division Accomplishment for 2018.
- Named IEEE Life Fellow, 2018
- Had research on "High-level entity resolution and integration across unstructured and semi-structured data sources" named as IBM Research Division Accomplishment for 2017.
- Laurea Honoris Causa, University of Calabria, November 2017 (most important honor given by the Italian university system).
- "Ron Fagin Special Event" was held at the 2016 ACM SIGMOD/PODS Conference "in honor of Ron Fagin's influential and long-lasting research contributions to the principles of database systems".
- Presented one of two "Gems of PODS" talks (for research on score aggregation) at the 2016 ACM SIGMOD/PODS Conference.
- Listed in American Men and Women of Science, 2016
- The paper "Data exchange: semantics and query answering" (coauthors Phokion Kolaitis, Renée J. Miller, and Lucian Popa) was named the second most highly cited paper of the decade 2005-2014 for the journal *Theoretical Computer Science*.

- Received IBM Corporate Award for "Pioneering Research in Rank and Score Aggregation", 2015.
- Received Best Paper Award, 2015 International Conference on Database Theory (ICDT), for the paper "A Declarative Framework for Linking Entities" (co-authors Douglas Burdick, Phokion Kolaitis, Lucian Popa, and Wang-Chiew Tan).
- Had research on "Rank and Score Aggregation" upgraded to an "Outstanding" IBM Research Division Accomplishment for 2014.
- Elected to the American Academy of Arts and Sciences, 2014.
- Elected to the US National Academy of Engineering, 2014, for "contributions to theory and practice of data management".
- Received Alberto O. Mendelzon Test-of-Time award of the 2014 ACM Symposium on Principles of Database Systems (PODS) for 2004 PODS paper "Composing schema mappings: second-order dependencies to the rescue" (coauthors Phokion Kolaitis, Lucian Popa and Wang-Chiew Tan).
- Received 2014 Gödel Prize for 2003 paper "Optimal aggregation algorithms for middleware" (coauthors Amnon Lotem and Moni Naor.
- Received Test-of-Time award of ICDT 2013 for 2003 ICDT paper "Data exchange: semantics and query answering" (coauthors Phokion Kolaitis, Renée J. Miller, and Lucian Popa)
- Named an IBM Fellow, 2012
- Received IEEE Computer Society W. Wallace McDowell Award (the highest award of the IEEE Computer Society) "for fundamental and lasting contributions to the theory of databases", 2012.
- Received Alberto O. Mendelzon Test-of-Time award of PODS 2011 for 2001 PODS paper "Optimal aggregation algorithms for middleware" (coauthors Amnon Lotem and Moni Naor).
- Received IEEE Technical Achievement Award (now called the Edward J. McCluskey Technical Achievement Award) "for pioneering contributions to the theory of rank and score aggregation", 2011.
- Received IBM Corporate Award for "Advances in Database Theory", 2010.
- Received Best Paper Award, 2010 ICDT, for the paper "Composition with target constraints" (coauthors Marcelo Arenas and Alan Nash).
- Had research on Tivoli Storage Manager (in particular differential backup) upgraded to an "Extraordinary"IBM Research Division Accomplishment for 2009.
- Received IBM Outstanding Innovation Award, 2009, for "Advances in database theory".

- Had research on "Schema mappings research: theory and practice" upgraded to an "Outstanding" IBM Research Division Accomplishment for 2007, and awarded an IBM Outstanding Technical Achievement Award for this work in 2008.
- Elected to IBM Academy of Technology, 2007, for "fundamental contributions to computer science theory and its application to IBM products'.
- The paper "Functional dependencies in a relational database and propositional logic" was selected as a significant paper published in the first 50 years of the IBM journals, 2007.
- Received IBM supplemental Patent Issue Award, given for key IBM patents, for encryption keys patent, 2007.
- Named Fellow of the American Association for the Advancement of Science, 2006, for "fundamental contributions to computational complexity theory, database theory, and the theory of multi-agent systems".
- Received IBM Outstanding Innovation Award, 2006, for foundations of schema mappings.
- Had research on "Foundations of schema mappings" named as IBM Research Division Accomplishment for 2005.
- Received Pat Goldberg Memorial Best Paper Award for one of the three Best IBM Research Papers in Computer Science, Electrical Engineering and Math published in 2004. for the paper "Composing schema mappings: second-order dependencies to the rescue" (coauthors Phokion Kolaitis, Lucian Popa and Wang-Chiew Tan).
- Received 2004 ACM SIGMOD Edgar F. Codd Innovations Award (a lifetime achievement award in database research) " for his influential and lasting contributions to the principles and the practice of database systems over a period spanning nearly three decades".
- Received IBM supplemental Patent Issue Award, given for key IBM patents, for differential backup patent, 2003.
- Received IBM Outstanding Innovation Award, 2002, for differential backup for Tivoli Storage Manager.
- Received award for one of the three Best IBM Research Papers in Computer Science, Electrical Engineering and Math published in 2001 for the paper "Optimal aggregation algorithms for middleware" (coauthors Amnon Lotem and Moni Naor).
- Had research on "Aggregation algorithms for middleware" named as IBM Research Division Accomplishment for 2001.
- Received IBM Outstanding Innovation Award, 2001, for research on aggregation algorithms for middleware.
- Named Docteur Honoris Causa, University of Paris, 2001.
- Received Best Paper Award, 2001 PODS, for the paper "Optimal aggregation algorithms for middleware" (coauthors Amnon Lotem and Moni Naor).

- Named Fellow of the ACM (Association for Computing Machinery), 2000, for "creating the field of finite model theory, and for fundamental research in relational database theory and in reasoning about knowledge".
- Had research on "Differential backup for Tivoli Storage Manager" named as IBM Research Division Accomplishment for 2000.
- Named Fellow of the IEEE (Institute of Electrical and Electronic Engineers), 1997, for "contributions to finite-model theory and to relational database theory".
- Received IBM Outstanding Innovation Award (jointly with Moshe Y. Vardi), 1992, for zero-one laws.
- Received IBM Outstanding Innovation Award (jointly with Joseph Y. Halpern and Moshe Y. Vardi), 1987, for research on reasoning about knowledge.
- Received MIT Press Publisher's Prize for Best Paper, 1985 International Joint Conference on Artificial Intelligence, for the paper "Belief, Awareness, and Limited Reasoning" (coauthor Joseph Y. Halpern).
- Received IBM Outstanding Innovation Award (jointly with Nicholas J. Pippenger and H. Raymond Strong), 1981, for developing extendible hashing, a fast access method for dynamic files.
- Received IBM Outstanding Innovation Award, 1981, for fundamental contributions to relational database theory.

Keynote Talks

- Finite Model Theory and Many-Valued Logic: Challenges and Interactions, 2022
- The one-year celebration of the IBM-Univ. of Sao Paolo Center for Artificial Intelligence, 2021
- IEEE International Conference on Data Mining, Beijing, 2019
- Israel Database Day, Technion, Haifa, 2017
- Big Data and Computational Intelligence Workshop, Beijing, 2016
- Hot Topics in High-Performance Distributed Computing Workshop, 2015
- ACM International Conference on Information and Knowledge Management, 2013
- Australasian Computer Science Week, 2009
- Milner Lecture, Univ. of Edinburgh, 2007
- International Workshop on Exchange and Integration of Data, 2006
- IEEE Symposium on Logic in Computer Science, 2000

- Association for Symbolic Logic Annual Meeting, 1999
- ACM Symposium on Principles of Database Systems, 1998
- International Conference on Database Theory, 1990
- International Colloquium on Automata, Languages, and Programming, 1984
- Colloquium on Trees in Algebra and Programming, 1983
- IBM Symposium on Mathematical Foundations of Computer Science, Japan, 1982

Program Committees Chaired

- International Conference on Database Theory, 2009
- ACM Symposium on Theory of Computing, 2005
- Theoretical Aspects of Reasoning about Knowledge, 1994
- ACM Symposium on Principles of Database Systems, 1984

Conference or selection committees

- Selectin committee, 2021, 2022, and 2023 IEEE Women of ENIAC Computer Pioneer Award
- Program committee, AAAI Colnference on Artificial Intelligence, 2021
- Program committee, ACM Symposium on Principles of Database Systems, 2020
- Program committee, ACM Symposium on Principles of Database Systems, 2018
- Invited papers committee, STOC Theory Fest, 2017
- Program committee, WebDB, 2016
- Program committee, Foundations of Information and Knowledge Systems, 2016
- Program committee, Scalable Uncertainty Management, 2015
- Program committee, Scalable Uncertainty Management, 2014
- Chair, International Conference on Database Theory Test-of-Time Award committee, 2014
- Program committee, Foundations of Information and Knowledge Systems, 2014
- Program committee, International Conference on Database Theory, 2014
- Program committee, SIGMOD/PODS PhD Symposium, 2013

- Program committee, Foundations of Information and Knowledge Systems, 2012
- Program committee, International Conference on Database Theory, 2012
- Program committee, Foundations of Information and Knowledge Systems, 2010
- Program committee, Workshop on Ranking in Databases, 2009
- Program committee, Alberto Mendelzon International Workshop on Foundations of Data Management, 2009
- Program committee chair, International Conference on Database Theory, 2009
- Program committee, ACM Symposium on Theory of Computing, 2008
- Program committee, ACM SIGMOD Conference, 2008
- Program committee, Very Large Data Bases Conference, 2008
- Program committee, Scalable Uncertainty Management, 2007
- Program committee, Flexible Query Answering Systems, 2006
- Program committee, International World Wide Web Conference, 2006
- Program committee chair, ACM Symposium on Theory of Computing, 2005
- Program committee, International World Wide Web Conference, 2004
- Program committee, Flexible Query Answering Systems, 2004
- Program committee, International Conference on Database Theory, 2003
- Program committee, Workshop on Distributed Data and Structures, 2002
- Program committee, ACM Symposium on Principles of Database Systems, 2002
- Program committee, BISC International Workshop on Fuzzy Logic and the Internet, 2001
- Program committee, ACM Symposium on Theory of Computing, 2001
- Program committee, ACM Symposium on Theory of Computing, 1999
- Program committee, Next Generation Information Technologies and Systems, Israel, 1999
- Program committee, International Conference on Database Theory, 1999
- Program committee chair, Theoretical Aspects of Reasoning about Knowledge, 1994
- Program committee, IEEE Symposium on Foundations of Computer Science, 1993
- Conference chair, Theoretical Aspects of Reasoning about Knowledge, 1992
- Program committee, Theoretical Aspects of Reasoning about Knowledge, 1992

- Program committee, Mathematical Fundamentals of Database and Knowledge Base Systems, 1991
- Program committee, ACM Symposium on Theory of Computing, 1990
- Member, Board of Directors, Theoretical Aspects of Reasoning about Knowledge (now Theoretical Aspects of Rationality and Knowledge), 1990–2023
- Program committee, Theoretical Aspects of Reasoning about Knowledge, 1990
- Program committee, Third Logical Biennial (Kleene '90), 1990
- Program committee, ACM Symposium on Theory of Computing, 1988
- Program committee, International Symposium on Model Theoretic Methods in Computer Science, 1984
- Program committee chair, ACM Symposium on Principles of Database Systems, 1984
- General chair, ACM Symposium on Principles of Database Systems, 1983
- Program committee, ACM Symposium on Theory of Computing, 1983
- Program committee, ACM Symposium on Principles of Database Systems, 1982
- Program committee, ACM SIGMOD Conference, 1979

Editorships

- Editor, Journal of Computer and System Sciences, 2007–present. Associate Editor, 1984–2007.
- Member, Editorial Board, Chicago Journal of Theoretical Computer Science, 1994–present
- Member, Editorial Board, Foundations and Trends in Databases, 2006–2014
- Member, Editorial Board, Methods of Logic in Computer Science, 1990–1996
- Editor of special issue of Theory of Computing Systems for ICDT '09
- Editor of special issue of SIAM J. Computing for STOC '05
- Editor of special issue of Journal of Computer and System Sciences for STOC '99
- Editor of special issue of Journal of Computer and System Sciences for PODS '92 (took over on the death of Paris Kanellakis)

Patents

Patents issued:

- Method and apparatus for incorporating weights into data combinational rules
  01/11/2000 Issued as Patent 6014664 in U.S.
  Co-inventor: E.L. Wimmers

- System and method for differential compression of data from a plurality of binary sources
  04/16/2002 Issued as Patent 6374250 in U.S.
  Co-inventors: M. Ajtai, R.C. Burns, L.J. Stockmeyer

- Digital pen using speckle tracking
  02/03/2004 Issued as Patent 6686579 in U.S.
  Co-inventors: H.J. Rosen, N. Megiddo, R.J. Morris, T.G. Zimmerman, S. Rajagopalan

- Static index pruning for information retrieval systems
  02/02/2005 Issued as Patent ZL0182128.8 in Canada
  02/15/2008 Issued as Patent 4080878 inn Japan
  09/19/2012 Issued as Patent 60147138 in Denmark
  09/19/2012 Issued as Patent 1346296 in France
  09/19/2012 Issued as Patent 1346296 in United Kingdom
  Co-inventors: D. Carmel, D. Cohen, E.D. Farchi, Y.S. Maarek, M. Herscovici, A.Y. Soffer

- Method for assigning encryption keys
  09/20/2005 Issued as Patent 6947563 in U.S.
  Co-inventors: M. Naor, D. Naor, J.B. Lotspiech, N. Megiddo

- Method for schema mapping and data transformation
  12/12/2006 Issued as Patent 7149746 in U.S.
  Co-inventors: R.E. Miller, M.A. Hernández, L. Haas, L. Popa, F.G. Naumann

- System, method, and service for ranking search results using a modular scoring system
  08/14/2007 Issued as Patent 7257277 in U.S.
  Co-inventors: J.A. Tomlin, K. Mc Curley, D. Sivakumar, J. Novak, D.P. Williamson, R. Kumar

- Lossy index compression
  02/15/2008 issued as Patent 4080878 in Japan
  04/08/2008 Issued as Patent 7356527 in U.S.
  Co-inventors: D. Carmel, D. Cohen, E.D. Farchi, Y.S. Maarek, M. Herscovici, A.Y. Soffer

- System and Method for Performing a High-Level Multi-Dimensional Query on a Multi-Structural Database
  04/14/2009 Issued as Patent 7519582 in U.S.
  Co-inventors: R. Guha, Ph. Kolaitis, R. Kumar, J. Novak, D. Sivakumar, and A. Tomkins.

- System and Method of Performing an Inverse Schema Mapping
  03/09/2010 Issued as Patent 7676484 in U.S.

- Sequential Composition of Schema Mappings
  03/30/2010 Issued as Patent 7689581 in U.S.
  Co-inventors: P. Kolaitis, L. Popa, W-C. Tan, and C. Yu.

- Quasi-inverses of Schema Mappings
  08/24/2010 Issued as Patent 7783680 in U.S.
  Co-inventors: P. Kolaitis, L. Popa, and W-C. Tan.

- Efficient Semi-supervised Concept Organization Accelerated Via Inequality Process
  2/2/2021 Issued as Patent 10902346 in U.S.
  Co-inventors: A. Alba, K. Clarkson, C. Drews, D. F. Gruhl, N. R. Lewis, P. N.. Mendes, M. Nagaraian, C. Ramakrishnan

Patents filed for by IBM:

- Optimal approximate approach to aggregating information
  05/21/2002 Filed as Docket ARC920020019US1 in U.S.

- System and method for translating data from a source schema to a target schema
  04/01/2003 Filed as Docket ARC920030001US1 in U.S.
  Co-inventors: R.E. Miller, M.A. Hernández, L. Popa.

- Efficient similarity search and classification via rank aggregation
  06/09/2003 Filed as Docket ARC920030029US1 in U.S.
  Co-inventors: D. Sivakumar, R. Kumar

Publications

- Representation theory for a class of denumerable Markov chains. *J. Math. Analysis and Applications* 23, 1968, pp. 500–530. (Senior Thesis, Dartmouth College.)

- *Contributions to the model theory of finite structures.* Doctoral dissertation, Univ. of California, Berkeley, June 1973.

- Generalized first-order spectra and polynomial-time recognizable sets. *Complexity of Computation*, ed. R. Karp, SIAM-AMS Proceedings 7, 1974, pp. 43–73.

- $L_{\kappa,\lambda}$–equivalence of ordinals and a compactness result. *Amer. Math. Soc. Notices* 21, 2, 1974, p. A–322.

- Monadic generalized spectra. *Zeitschr. f. math. Logik und Grundlagen d. Math.* (now *Mathematical Logic Quarterly*) 21, 1975, pp. 89–96.

- A two–cardinal characterization of double spectra. *Zeitschr. f. math. Logik und Grundlagen d. Math.* (now *Mathematical Logic Quarterly*) 21, 1975, pp. 121–122.

- A spectrum hierarchy. *Zeitschr. f. math. Logik und Grundlagen d. Math.* (now *Mathematical Logic Quarterly*) 21, 1975, pp. 123–134.

- The independence of miss ratio on page size, with Malcolm C. Easton. *J. ACM* 23, 1, Jan. 1976, pp. 128–146.
- A counterintuitive example of computer paging. *Comm. ACM* 19, 2, Feb. 1976, pp. 96–97. Corrigendum: *Comm. ACM* 19, 4, April 1976, p. 187.
- Probabilities on finite models. *J. Symbolic Logic* 41, 1, March 1976, pp. 50–58. Abstract appeared in *Notices Amer. Math. Soc.*, 1972, A714 (Abstract no. 72T-E90).
- Asymptotic miss ratios over independent references. *J. Computer and System Sciences* 14, 2, April 1977, pp. 222–250.
- A complete axiomatization for functional and multivalued dependencies in database relations, with Catriel Beeri and John H. Howard, Jr. *Proc. 1977 ACM SIGMOD Symposium*, ed. D. C. P. Smith, Toronto, pp. 47–61.
- The number of finite relational structures. *Discrete Math.* 19, 1, July 1977, pp. 17–21.
- Multivalued dependencies and a new normal form for relational databases. *ACM Trans. on Database Systems* 2, 3, Sept. 1977, pp. 262–278.
- The decomposition versus the synthetic approach to relational database design. *Proc. 1977 Very Large Data Bases Conference*, Tokyo, pp. 441–446. Reprinted in: *Tutorial: Data Base Management in the 1980's*, ed. J. A. Larson and H. A. Freeman, IEEE Computer Society, NY, 1981, pp. 269–274.
- Functional dependencies in a relational database and propositional logic. *IBM J. Research and Development* 21, 6, Nov. 1977, pp. 534–544.
- Efficient calculation of expected miss ratios in the independent reference model, with Thomas G. Price. *SIAM J. Computing* 7, 3, Aug. 1978, pp. 288–297.
- On an authorization mechanism. *ACM Trans. on Database Systems* 3, 3, Sept. 1978, pp. 310–319.
- Cold–start vs. warm–start miss ratios, with Malcolm C. Easton. *Comm. ACM* 21, 10, Oct. 1978, pp. 866–871.
- Normal forms and relational database operators. *Proc. 1979 ACM SIGMOD Conference*, ed. P. A. Bernstein, pp. 153–160.
- Extendible hashing—a fast access method for dynamic files, with Jurg Nievergelt, Nicholas J. Pippenger, and H. Raymond Strong. *ACM Trans. on Database Systems* 4, 3, Sept. 1979, pp. 315–344.
- An equivalence between relational database dependencies and a fragment of propositional logic, with Yehoshua Sagiv, Claude Delobel, and D. Stott Parker, Jr. *J. ACM* 28, 3, July 1981, pp. 435–453. Corrigendum: *J. ACM* 34, 4, Oct. 1987, pp. 1016–1018.
- A note on the existence of continuous functionals, with J. Lawrence Carter. *Theoretical Computer Science* 16, 1981, pp. 231–235.

- A normal form for relational databases that is based on domains and keys. *ACM Trans. on Database Systems* 6, 3, Sept. 1981, pp. 387–415.
- Properties of acyclic database schemes, with Catriel Beeri, David Maier, Alberto Mendelzon, Jeffrey D. Ullman, and Mihalis Yannakakis. *Proc. 13th ACM Symposium on the Theory of Computing*, 1981, pp. 355–362.
- Armstrong databases. **Invited paper**, *Proc. 7th IBM Symposium on Mathematical Foundations of Computer Science*, Kanagawa, Japan, May 1982.
- A simplified universal relation assumption and its properties, with Alberto Mendelzon and Jeffrey D. Ullman. *ACM Trans. on Database Systems* 7, 3, Sept. 1982, pp. 343–360.
- Horn clauses and database dependencies. *J. ACM* 29, 4, Oct. 1982, pp. 952–985. Preliminary version appeared in *Proc. 12th ACM Symposium on the Theory of Computing*, 1980, pp. 123–134.
- Armstrong databases for functional and inclusion dependencies, with Moshe Y. Vardi. *Information Processing Letters* 16, Jan. 1983, pp. 13–19.
- Tools for template dependencies, with David Maier, Jeffrey D. Ullman, and Mihalis Yannakakis. *SIAM J. Computing* 12, 1, Feb. 1983, pp. 36–59.
- On the semantics of updates for databases, with Jeffrey D. Ullman and Moshe Y. Vardi. *Proc. 2nd ACM Symposium on Principles of Database Systems*, Atlanta, 1983, pp. 352–365.
- A fair carpool scheduling algorithm, with John H. Williams. *IBM J. Research and Development* 27, 2, March 1983, pp. 133–139.
- Acyclic database schemes of various degrees: a painless introduction. **Invited paper**, *Proc. CAAP83 8th Colloquium on Trees in Algebra and Programming*, Springer–Verlag Lecture Notes in Computer Science 159, 1983, ed. G. Ausiello and M. Protasi, pp. 65–89.
- Degrees of acyclicity for hypergraphs and relational database schemes. *J. ACM* 30, 3, July 1983, pp. 514–550.
- On the desirability of acyclic database schemes, with Catriel Beeri, David Maier, and Mihalis Yannakakis. *J. ACM* 30, 3, July 1983, pp. 479–513.
- On the structure of Armstrong relations for functional dependencies, with Catriel Beeri, Martin Dowd, and Richard Statman. *J. ACM* 31, 1, Jan. 1984, pp. 30–46.
- Inclusion dependencies and their interaction with functional dependencies, with Marco Casanova and Christos Papadimitriou. *J. Computer and System Sciences* 28, 1, Feb. 1984, pp. 29–59. Preliminary version appeared in *Proc. 1st ACM Symposium on Principles of Database Systems*, Los Angeles, March 1982, pp. 171–176.

- The theory of data dependencies: an overview, with Moshe Y. Vardi. **Invited paper**, *Proc. 11th International Colloquium on Automata, Languages, and Programming*, Antwerp, July 1984. Appeared in Springer–Verlag Lecture Notes in Computer Science 172, 1984, ed. J. Paradaens, pp. 1–22.

- Decreasing the nesting depth of expressions involving square roots, with Allan Borodin, John Hopcroft, and Martin Tompa. *Journal of Symbolic Computation* 1, 1985, pp. 169–188.

- An internal semantics for modal logic, with Moshe Y. Vardi. *Proc. 17th ACM Symposium on Theory of Computing*, Providence, RI, May 1985, pp. 305–315.

- Bounded depth, polynomial–size circuits for symmetric functions, with Maria M. Klawe, Nicholas J. Pippenger, and Larry J. Stockmeyer. *Theoretical Computer Science* 36, 2–3, April 1985, pp. 239–250.

- Knowledge and implicit knowledge in a distributed environment, with Moshe Y. Vardi. *Conf. on Theoretical Aspects of Reasoning about Knowledge*, ed. J. Y. Halpern, Morgan Kaufmann, 1986, pp. 187–206.

- Updating logical databases, with Gabriel Kuper, Jeffrey D. Ullman, and Moshe Y. Vardi. *Advances in Computing Research*, vol. 3, The Theory of Databases, ed. P. Kanellakis and F. P. Preparata, JAI Press, Greenwich, Conn., 1986, pp. 1–18.

- The theory of data dependencies: a survey, with Moshe Y. Vardi. *Mathematics of Information Processing*, Proceedings of Symposia in Applied Mathematics, American Mathematical Society, 1986, vol. 34, pp. 19–72.

- A simple characterization of database dependency implication, with Yoshito Hanatani. *Information Processing Letters* 22, 6, May 1986, 281–283.

- Belief, awareness, and limited reasoning, with Joseph Y. Halpern. *Artificial Intelligence* 34, 1988, pp. 39–76. Preliminary version appeared in *International Joint Conference on Artificial Intelligence* (IJCAI–85), Aug. 1985, pp. 491–501.

- Mofprizeling knowledge and action in distributed systems, with Joseph Y. Halpern. *Distributed Computing* 3, 4, 1989, pp. 159–179. Preliminary version appeared under the title "A formal model of knowledge, action, and communication in distributed systems" in *ACM Symposium on Principles of Distributed Computing*, 1985, pp. 224–236. Abridged version appeared in *Proc. Concurrency 88*, 1988, ed. F. H. Vogt, pp. 18–32.

- I'm OK if you're OK: On the notion of trusting communication, with Joseph Y. Halpern, *J. of Philosophical Logic* 17, 4, Nov. 1988, 329–354. Reprinted in *Philosophical Logic and Artificial Intelligence*, ed. R. Thomason, Kluwer, 1989, pp. 9–34. Preliminary version appeared in *Proc. IEEE Symposium on Logic in Computer Science*, June 1987, pp. 280–292.

- Reachability is harder for directed than for undirected finite graphs, with Miklos Ajtai. *J. Symbolic Logic* 55, 1, March 1990, pp. 113–150. Preliminary version appeared in *Proc. 29th IEEE Symposium on Foundations of Computer Science*, 1988, pp. 358–367.

- A logic for reasoning about probabilities, with Joseph Y. Halpern and Nimrod Megiddo. *Information and Computation* 87, July/Aug. 1990, pp. 78–128. (Special issue for selected papers from the 1988 IEEE Symposium on Logic in Computer Science Conference).

- Uncertainty, belief, and probability, with Joseph Y. Halpern. *Computational Intelligence* 7, 1991, pp. 160–173. Preliminary version appeared in *International Joint Conference on Artificial Intelligence* (IJCAI–89), pp. 1161–1167.

- A model–theoretic analysis of knowledge, with Joseph Y. Halpern and Moshe Y. Vardi. *J. ACM* 91, 2, April 1991, pp. 382–428. Preliminary version appeared in *Proc. 25th IEEE Symposium on Foundations of Computer Science*, West Palm Beach, Florida, Oct. 1984, pp. 268–278.

- Database systems: achievements and opportunities, *Comm. ACM* 34, 10, Oct. 1991, pp. 110–120, ed. A. Silberschatz, M. Stonebraker, and J. Ullman. The report was drafted by the NSF Invitational Workshop on Future Directions in DBMS Research, Feb. 22–23, 1990, of which I was a member (the other invitees were Michael Brodie, Peter Buneman, Michael Carey, Ashok Chandra, Hector Garcia-Molina, Jim Gray, David Lomet, David Maier, Marie Ann Niemat, Avi Silberschatz, Michael Stonebraker, Irving Traiger, Jeffrey Ullman, Gio Wiederhold, Carlo Zaniolo, and Maria Zemankova).

- A new approach to updating beliefs, with Joseph Y. Halpern. In *Uncertainty in Artificial Intelligence: Volume VI*, ed. P. P. Bonissone, M. Henrion, L. N. Kanal and J. Lemmer, Elsevier, 1991, pp. 347–374. Preliminary version appeared in *Conference on Uncertainty in AI*, 1990, pp. 317–324.

- What can machines know? On the properties of knowledge in distributed systems, with Joseph Y. Halpern and Moshe Y. Vardi. *J. ACM* 39, 2, 1992, pp. 328–376. Preliminary version appeared under the name "What can machines know? On the epistemic properties of machines" in *National Conference on Artificial Intelligence* (AAAI–86), 1986, pp. 428–434.

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