

## Edward P. “Ted” Wobber

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RESEARCH INTERESTS	Distributed systems, operating systems, security, storage systems	
EDUCATION	Harvard College, Cambridge, Massachusetts, USA A.B., Physics, 1975	
EMPLOYMENT	Principal Researcher Microsoft Research Silicon Valley	Microsoft Corporation 2001-present
	Principal Member Technical Staff (and Senior Consulting Engineer) Systems Research Center, Palo Alto, CA	Digital Equipment Corporation 1985-2001
	Software Engineer Mountain View, CA	3Com Corporation 1984-1985
	Senior Member Programming Staff Systems Software Division, Palo Alto, CA	Xerox Corporation 1981-1984
	Member Programming Staff Advanced Systems Development, Palo Alto, CA	Xerox Corporation 1979-1981
	Systems Analyst Wilmington, MA	Compugraphic Corporation 1978-1979
	Systems Programmer Braintree, MA	Interactive Sciences Corporation 1976-1978
SIGNIFICANT RESEARCH PROJECTS	<p><i>Totient.</i> In this work, we explore the properties of the global PKI as it exists in practice. Specifically, we analyze a large collection of certificates as to their compliance with the CA/B Forum guidelines. From this data, we can build a visualization tool that depicts a map of the Web PKI whose elements are clusters of similar certificates parameterized with compliance data. From this vantage point, we can then build tools that offer flexible mechanisms for observers to fashion individualized policies to determine certificate trust. [10, 35]</p> <p><i>CORFU.</i> In this work, we propose a cluster of network-attached flash exposed as a global shared log. CORFU has two primary goals. As a shared log, it exploits flash storage to alter the trade-off between performance and consistency, supporting applications such as databases at wire speed. As a distributed SSD, it slashes power consumption and infrastructure cost by eliminating storage servers. Unlike conventional single-machine SSDs, CORFU’s distributed nature enables fault-tolerance to machine and rack failures, as well as incremental scaling of capacity and throughput. CORFU also avoids the bandwidth bottlenecks present in high-performance SSD servers by distributing flash capacity throughout the data center. [1, 12, 14]</p> <p>In recent related work, we explore CORFU as a general mechanism for establishing total order in distributed systems, absent non-volatile memory. We also develop systems for implementing in-memory objects in high-level programming languages, such as Java or .net collections, which are</p>	

made persistent and fault-tolerant by a shared log and which support rich transactional semantics. [2, 11, 41]

*Community Information Management.* This project is exploring system support for loosely structured, semitrustful communities with shared information needs. In this context, we are conducting fundamental research in a number of areas that go beyond storage and communication including identity, trust, replication, provenance, and contextual awareness. I have contributed to all aspects of this work while maintaining responsibility for its security component. [3, 16, 18, 19, 20, 21, 37, 44]

*Flashlight.* The Flashlight project is exploring existing and new non-volatile memory (NVRAM) architectures and building tools to aid in that endeavor. As part of this work, I helped design a novel and efficient stable metadata representation for flash disks, and led an first-principles study into the constraints on NAND solid-state disk performance. In addition, we made a public release of a trace-based simulator for experimenting with various SSD internal configurations. [4, 17, 22, 36, 45]

*Singularity.* The Singularity project focused on the construction of dependable systems through innovation in the areas of systems, languages, and tools. We built a research operating system prototype that employed programming languages extensions, and utilized new techniques and tools for specifying and verifying program behavior. I designed and built the security subsystem for this prototype OS. [24, 25, 38, 39, 47]

*Penny Black.* The Penny Black project investigated several techniques to reduce spam by making the sender pay. We considered several currencies for payment: CPU cycles, memory cycles, Turing tests (proof that a human was involved), and plain old cash. We also explored new mechanisms for deploying payment schemes. [5, 27, 28]

*Personal Jukebox* We prototyped and marketed this portable, battery-operated, hard-disk-based MP3 player several years before the advent of the iPod. I contributed to the PJB file system design and built much of the PC software to load music into it. [49, 50]

*Pachyderm.* An elephant never forgets. This web-based, indexed mail repository made it easy to store email forever, and get it back when you want it. As part of this work, we invented numerous fundamental abstractions, such as indexed labels and query-based mail access, that are commonly found in modern mail agents such as Gmail. I designed and built the indexed mail store for this prototype. [51, 52]

*AltaVista.* I designed and implemented the "advanced query" operation for the Alta Vista search engine (the first internet-scale web search engine).

*Network Objects.* We designed and built a system for object-oriented distributed programming. Our so-called Network Objects are tightly integrated into the Modula-3 programming language and offer type-safety, dynamic typing, and garbage collection in a distributed environment. Subsequent work added security properties to the system. I implemented most of the base system, and was responsible for an expanded journal article describing it. [7, 31, 53]

*Taos authentication.* We designed and built the authentication mechanism for SRC's Taos operating system. We proposed a new "speaks for" logic to formalize our design and motivate our implementation. In this work, we introduced the notion of compound principal to describe the precise source of authenticated requests in a distributed system, for example: a delegation from a smart-card, a program acting as a privileged agent, or an encrypted channel acting on behalf of a node. I designed and implemented this Taos security component, and was first author on the paper describing it. [8, 9, 32, 33]

HONORS

ACM Distinguished Scientist (2009)

SERVICE  
ACTIVITIES

Program Committees:

The Eighth International World Wide Web Conference (1998)  
The Nineteenth ACM Symposium on Operating Systems Principles (2003)  
The Second International Workshop on Storage Security and Survivability (2006)  
Joint IFIP TC6/TC11 Conference on Communications and Multimedia Security (2011,2012,2013,2014)  
The European Conference on Computer Systems (2014)

National Science Foundation Panelist (2006,2007)

Reviewer for the following conferences: SOSP, OSDI, NSDI, ACM CCS, WWW, IEEE Security and Privacy, FAST, CEAS (Email/Anti-Spam), DSN, and MobiSys; and the following journals: ACM Transactions on Information and System Security, IEEE Security and Privacy, Journal of Systems and Software, IEEE Transactions on Computers, and IEEE Computer Architecture Letters.

General Chair, ACM Symposium on Operating Systems Principles 2011

PATENTS

19 United States patents issued, 13 pending

JOURNAL  
ARTICLES

- [1] Mahesh Balakrishnan, Dahlia Malkhi, John Davis, Vijayan Prabhakaran, Michael Wei, and Ted Wobber. CORFU: A distributed shared log. *ACM Transactions on Computer Systems*, 2013.
- [2] Dahlia Malkhi, Mahesh Balakrishnan, John Davis, Vijayan Prabhakaran, and Ted Wobber. From Paxos to CORFU: A flash-speed shared log. *ACM SIGOPS Operating Systems Reviews*, 46(1):47–51, 2012.
- [3] Venugopalan Ramasubramanian, Kaushik Veeraraghavan, Krishna P.N. Puttaswamy, Thomas L. Rodeheffer, Douglas B. Terry, and Ted Wobber. Fidelity-aware replication for mobile devices. *IEEE Transactions on Mobile Computing*, 9(12):1697–1712, 2010.
- [4] Andrew Birrell, Michael Isard, Chuck Thacker, and Ted Wobber. A design for high-performance flash disks. *SIGOPS Operating Systems Review*, 41(2):88–93, 2007.
- [5] Martín Abadi, Mike Burrows, Mark Manasse, and Ted Wobber. Moderately hard, memory-bound functions. *ACM Transactions on Internet Technology*, 5(2):299–327, 2005.
- [6] Kenneth Alden and Edward Wobber. The AltaVista Tunnel: Using the internet to extend corporate networks. *Digital Technical Journal*, 9(2):5–15, 1997.
- [7] Andrew Birrell, Greg Nelson, Susan Owicki, and Edward Wobber. Network objects. *Software: Practice and Experience*, 25(S4):87–130, 1995.
- [8] Edward Wobber, Martín Abadi, Michael Burrows, and Butler Lampson. Authentication in the Taos operating system. *ACM Transactions on Computer Systems*, 12(1):3–32, 1994.
- [9] Butler Lampson, Martín Abadi, Michael Burrows, and Edward Wobber. Authentication in distributed systems: theory and practice. *ACM Transactions on Computer Systems*, 10(4):265–310, 1992.

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PROCEEDINGS

- [10] Antoine Delignat-Lavaud, Martin Abadi, Andrew Birrell, Ilya Mironov, Ted Wobber, and Yinglian Xie. Web pki: Closing the gap between guidelines and practices. In *Proceedings of NDSS'14*. Internet Society, February 2014.
- [11] Mahesh Balakrishnan, Dahlia Malkhi, Ted Wobber, Ming Wu, Vijayan Prabhakaran, Micheal Wei, John D. Davis, Sriram Rao, Tao Zou, and Aviad Zuck. Tango: Distributed data structures over a shared log. In *Proceedings of the 24th ACM Symposium on Operating Systems Principles*, 2013.
- [12] Michael Wei, John D. Davis, Ted Wobber, Mahesh Balakrishnan, and Dahlia Malkhi. Beyond block I/O: Implementing a distributed shared log in hardware. In *SYSTOR 2013 (the 6th International Systems and Storage Conference)*, 2013.
- [13] Catherine C. Marshall, Ted Wobber, Venugopalan Ramasubramanian, and Douglas B. Terry. Supporting research collaboration through bi-level file synchronization. In *Proceedings of Group 2012*, 2012 (Honorable Mention).
- [14] Mahesh Balakrishnan, Dahlia Malkhi, Vijayan Prabhakaran, Ted Wobber, Michael Wei, and John Davis. CORFU: A shared log design for flash clusters. In *9th USENIX Symposium on Networked Systems Design and Implementation (NSDI '12)*, 2012.
- [15] Patrick Stuedi, Iqbal Mohamed, Mahesh Balakrishnan, Venugopalan Ramasubramanian, Doug Terry, Ted Wobber, and Z. Morley Mao. Contrail: Enabling decentralized social networks on smartphones. In *Middleware 2011: ACM/IFIP/USENIX 12th International Middleware Conference*, 2011 (Best Paper).
- [16] Krishna P.N. Puttaswamy, Catherine C. Marshall, Venugopalan Ramasubramanian, Patrick Stuedi, Douglas B. Terry, and Ted Wobber. Docx2go: Collaborative editing of fidelity reduced documents on mobile devices. In *MobiSys '10: Proceedings of the 8th International Conference on Mobile Systems, Applications, and Services*, 2010.

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- [19] Kaushik Veeraraghavan, Venugopalan Ramasubramanian, Thomas L. Rodeheffer, Douglas B. Terry, and Ted Wobber. Fidelity-aware replication for mobile devices. In *MobiSys 2009: The 7th Annual International Conference on Mobile Systems, Applications and Services*, 2009.
- [20] Venugopalan Ramasubramanian, Thomas L. Rodeheffer, Douglas B. Terry, Meg Walraed-Sullivan, Ted Wobber, Catherine C. Marshall, and Amin Vahdat. Cimbiosys: A platform for content-based partial replication. In *Proceedings of 6th USENIX Symposium on Networked Systems Design and Implementation*, pages 261–276, 2009.
- [21] Prince Mahajan, Ramakrishna Kotla, Catherine C. Marshall, Venugopalan Ramasubramanian, Thomas L. Rodeheffer, Douglas B. Terry, and Ted Wobber. Effective and efficient compromise recovery for weakly consistent replication. In *EuroSys '09: Proceedings of the Fourth ACM European Conference on Computer Systems*, pages 131–144, 2009.
- [22] Nitin Agrawal, Vijayan Prabhakaran, Ted Wobber, John D. Davis, Mark Manasse, and Rina Panigrahy. Design tradeoffs for SSD performance. In *USENIX Annual Technical Conference*, pages 57–70, 2008.
- [23] Yinglian Xie, Fang Yu, Kannan Achan, Eliot Gillum, Moises Goldszmidt, and Ted Wobber. How dynamic are IP addresses? In *SIGCOMM '07: Proceedings of the 2007 ACM Conference on Applications, Technologies, Architectures, and Protocols for Computer Communications*, pages 301–312, 2007.
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- [25] Galen Hunt, Mark Aiken, Manuel Fähndrich, Chris Hawblitzel, Orion Hodson, James Larus, Steven Levi, Bjarne Steensgaard, David Tarditi, and Ted Wobber. Sealing OS processes to improve dependability and safety. In *EuroSys '07: Proceedings of the 2nd ACM SIGOPS/EuroSys European Conference on Computer Systems 2007*, pages 341–354, 2007.
- [26] Martín Abadi and Ted Wobber. A logical account of NGSCB. In *Proceedings of Formal Techniques for Networked and Distributed Systems (Forte '04)*. Springer-Verlag, 2004.
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- [29] Martín Abadi, Andrew Birrell, Raymie Stata, and Edward Wobber. Secure web tunneling. In *Proceedings of the 7th International World Wide Web Conference*, pages 531–539, 1998.
- [30] Leendert Van Doorn, Martín Abadi, Mike Burrows, and Edward Wobber. Secure network objects. In *Proceedings of the 1996 IEEE Symposium on Security and Privacy*, pages 211–221, 1996.
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- [33] Butler Lampson, Martín Abadi, Michael Burrows, and Edward Wobber. Authentication in distributed systems: theory and practice. In *SOSP '91: Proceedings of the Thirteenth ACM Symposium on Operating Systems Principles*, pages 165–182, 1991.
- [34] Andrew Birrell, Michael B. Jones, and Edward Wobber. A simple and efficient implementation of a small database. In *SOSP '87: Proceedings of the Eleventh ACM Symposium on Operating Systems Principles*, pages 149–154, 1987.

WORKSHOP  
PROCEEDINGS

- [35] Martn Abadi, Andrew Birrell, Ilya Mironov, Ted Wobber, and Yinglian Xie. Global authentication in an untrustworthy world. In *14th Workshop on Hot Topics in Operating Systems (HotOS XIV)*, 2013.
- [36] Vijayan Prabhakaran, Mahesh Balakrishnan, John D. Davis, and Ted Wobber. Depletable storage systems. In *Proceedings of 2nd Workshop on Hot Topics in Storage and File Systems*, 2010.
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- [38] Martín Abadi, Andrew Birrell, and Ted Wobber. Access control in a world of software diversity. In *Proceedings of the 10th Workshop on Hot Topics in Operating Systems (HotOS X)*. USENIX, 2005.
- [39] Galen Hunt, James R. Larus, David Tarditi, and Ted Wobber. Broad new OS research: Challenges and opportunities. In *Proceedings of the 10th Workshop on Hot Topics in Operating Systems (HotOS X)*. USENIX, 2005.
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PUBLICATIONS

- [41] Michael Wei, Mahesh Balakrishnan, John D. Davis, Dahlia Malkhi, Vijayan Prabhakaran, and Ted Wobber. Dynamically scalable, fault-tolerant coordination on a shared logging service. Microsoft Research Technical Report MSR-TR-2013-40, Microsoft Corporation, 2013.
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- [43] Patrick Stuedi, Iqbal Mohamed, Mahesh Balakrishnan, Venugopalan Ramasubramanian, Doug Terry, Ted Wobber, and Z. Morley Mao. Contrail: Enabling decentralized social networks on smartphones. Microsoft Research Technical Report MSR-TR-2010-132, Microsoft Corporation, 2010.
- [44] Ted Wobber, Thomas L. Rodeheffer, and Douglas B. Terry. Policy-based access control for peer-to-peer replication. Microsoft Research Technical Report MSR-TR-2009-15, Microsoft Corporation, 2009.
- [45] Vijayan Prabhakaran and Ted Wobber. SSD extension for disksim simulation environment (software download). <http://research.microsoft.com/en-us/downloads/b41019e2-1d2b-44d8-b512-ba35ab814cd4>, 2009.
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- [47] Galen Hunt, James R. Larus, Martín Abadi, Mark Aiken, Paul Barham Manuel Fähndrich, Chris Hawblitzel, Orion Hodson, Steven Levi, Nick Murphy, Bjarne Steensgaard, David Tarditi, Ted Wobber, and Brian D. Zill. An overview of the singularity project. Microsoft Research Technical Report MSR-TR-2005-135, Microsoft Corporation, 2005.
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- [51] Andrew Birrell, Mike Schroeder, Raymie Stata, and Ted Wobber. Pachyderm: a strategy for working on the web. <http://birrell.org/andrew/talks/pachyderm2.pdf>, 1997.
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