

References

- [1] K. A. V. P. M. Shaaban, and W. C.L. Heterogeneous computing: Challenges and opportunities. In *IEEE Computer*, 1993.
- [2] S. Akoush, L. Carata, R. Sohan, and A. Hopper. Mrlazy: Lazy runtime label propagation for mapreduce. In *Proceedings of the 6th USENIX Conference on Hot Topics in Cloud Computing*, HotCloud'14, pages 17–17, Berkeley, CA, USA, 2014. USENIX Association. URL <http://dl.acm.org/citation.cfm?id=2696535.2696552>.
- [3] C. S. Alliance. Top threats to cloud computing v1.0. <https://cloudsecurityalliance.org/topthreats/csathreats.v1.0.pdf>, Feb. 2010.
- [4] M. Armbrust, R. S. Xin, C. Lian, Y. Huai, D. Liu, J. K. Bradley, X. Meng, T. Kaftan, M. J. Franklin, A. Ghodsi, et al. Spark sql: Relational data processing in spark. In *Proceedings of the 2015 ACM SIGMOD International Conference on Management of Data*, pages 1383–1394. ACM, 2015.
- [5] S. Bajaj and R. Sion. Trusteddb: A trusted hardware based database with privacy and data confidentiality. In *Proceedings of the 2011 ACM SIGMOD International Conference on Management of Data*, SIGMOD '11, pages 205–216, New York, NY, USA, 2011. ACM. ISBN 978-1-4503-0661-4. doi: 10.1145/1989323.1989346. URL <http://doi.acm.org/10.1145/1989323.1989346>.
- [6] J. Bell and G. Kaiser. Phosphor: Illuminating dynamic data flow in commodity jvms. In *Proceedings of the 2014 ACM International Conference on Object Oriented Programming Systems Languages & Applications*, OOPSLA '14, pages 83–101, New York, NY, USA, 2014. ACM. ISBN 978-1-4503-2585-1. doi: 10.1145/2660193.2660212. URL <http://doi.acm.org/10.1145/2660193.2660212>.
- [7] C. B.W.L., W. C.L., and K. Hwang. A migrating-home protocol for implementing scope consistency model on a cluster of workstations. In *PDPTA*, 1999.
- [8] Z. Chothia, J. Liagouris, F. McSherry, and T. Roscoe. Explaining outputs in modern data analytics. *Proceedings of the VLDB Endowment*, 9(12):1137–1148, 2016.
- [9] H. Cui, J. Wu, C.-C. Tsai, and J. Yang. Stable deterministic multithreading through schedule memoization. In *Proceedings of the Ninth Symposium on Operating Systems Design and Implementation (OSDI '10)*, Oct. 2010.
- [10] H. Cui, J. Wu, J. Gallagher, H. Guo, and J. Yang. Efficient deterministic multithreading through schedule relaxation. In *Proceedings of the 23rd ACM Symposium on Operating Systems Principles (SOSP '11)*, pages 337–351, Oct. 2011.
- [11] H. Cui, J. Simsa, Y.-H. Lin, H. Li, B. Blum, X. Xu, J. Yang, G. A. Gibson, and R. E. Bryant. Parrot: a practical runtime for deterministic, stable, and reliable threads. In *Proceedings of the 24th ACM Symposium on Operating Systems Principles (SOSP '13)*, Nov. 2013.
- [12] H. Cui, R. Gu, C. Liu, and J. Yang. Paxos made transparent. In *Proceedings of the 25th ACM Symposium on Operating Systems Principles (SOSP '15)*, Oct. 2015.
- [13] A. Dave and M. Zaharia. Arthur: Rich post-facto debugging for production analytics applications.
- [14] J. Dean and S. Ghemawat. Mapreduce: simplified data processing on large clusters. In *OSDI'04: Proceedings of the 6th conference on Symposium on Operating Systems Design & Implementation*, pages 10–10, 2004.
- [15] C. Dwork. Differential privacy. *Lecture Notes in Computer Science*, 26(2):1–12, 2006.
- [16] C. Dwork. Differential privacy: A survey of results. In *International Conference on Theory and Applications of MODELS of Computation*, pages 1–19, 2008.
- [17] C. Dwork. A firm foundation for private data analysis. *Communications of The ACM*, 54(1):86–95, 2011.
- [18] C. Dwork and J. Lei. Differential privacy and robust statistics. In *Proceedings of the forty-first annual ACM symposium on Theory of computing*, pages 371–380. ACM, 2009.
- [19] C. Dwork, F. McSherry, K. Nissim, and A. Smith. Calibrating noise to sensitivity in private data analysis. In *TCC*, volume 3876, pages 265–284. Springer, 2006.
- [20] C. Dwork, F. McSherry, K. Nissim, and A. Smith. Calibrating noise to sensitivity in private data analysis. In *Proceedings of the Third Conference on Theory of Cryptography*, TCC'06, pages 265–284, Berlin, Heidelberg, 2006. Springer-Verlag. ISBN 3-540-32731-2, 978-3-540-32731-8. doi: 10.1007/11681878_14. URL http://dx.doi.org/10.1007/11681878_14.
- [21] T. ElGamal. A public key cryptosystem and a signature scheme based on discrete logarithms. *IEEE transactions on information theory*, 31(4):469–472, 1985.
- [22] W. Enck, P. Gilbert, B.-G. Chun, L. P. Cox, J. Jung, P. McDaniel, and A. N. Sheth. TaintDroid: an information-flow tracking system for realtime privacy monitoring on smartphones. In *Proceedings of the Ninth Symposium on Operating Systems Design and Implementation (OSDI '10)*, pages 1–6, 2010.
- [23] L. Feng, L. F.C.M., C. Heming, and W. Cho-Li. Confluence: Speeding up iterative distributed operations by key-dependency-aware partitioning. In *IEEE Transactions on Parallel and Distributed Systems (TPDS)*, 2017.
- [24] T. Frassetto, D. Gens, C. Liebchen, and A.-R. Sadeghi. Jitguard: Hardening just-in-time compilers with sgx. 2017.
- [25] C. Gentry, S. Halevi, and N. P. Smart. Homomorphic evaluation of the aes circuit. In *Advances in Cryptology-CRYPTO 2012*, pages 850–867. Springer, 2012.
- [26] C. Gentry et al. Fully homomorphic encryption using ideal lattices. In *STOC*, volume 9, pages 169–178, 2009.

- [27] M. A. Gulzar, M. Interlandi, S. Yoo, S. D. Tetali, T. Condie, T. Millstein, and M. Kim. Bigdebug: Debugging primitives for interactive big data processing in spark. In *Proceedings of the 38th International Conference on Software Engineering, ICSE '16*, pages 784–795, New York, NY, USA, 2016. ACM. ISBN 978-1-4503-3900-1. doi: 10.1145/2884781.2884813. URL <http://doi.acm.org/10.1145/2884781.2884813>.
- [28] X. Hu, M. Yuan, J. Yao, Y. Deng, L. Chen, Q. Yang, H. Guan, and J. Zeng. Differential privacy in telco big data platform. *Proceedings of the VLDB Endowment*, 8(12):1692–1703, 2015.
- [29] Intel. Software guard extensions programming reference. <https://software.intel.com/sites/default/files/329298-001.pdf>.
- [30] M. Interlandi, K. Shah, S. D. Tetali, M. A. Gulzar, S. Yoo, M. Kim, T. Millstein, and T. Condie. Titian: Data provenance support in spark. *Proc. VLDB Endow.*, 9(3):216–227, Nov. 2015. ISSN 2150-8097. doi: 10.14778/2850583.2850595. URL <http://dx.doi.org/10.14778/2850583.2850595>.
- [31] J. Jianyu, Z. Shixiong, A. Danish, W. Yuxuan, C. Heming, L. Feng, and G. Zhaoquan. Kakute: A precise, unified information flow analysis system for big-data security. In *Proceedings of the Annual Computer Security Applications Conference (ACSAC '17)*, 2017.
- [32] Z. Jorgensen, T. Yu, and G. Cormode. Conservative or liberal? personalized differential privacy. In *Data Engineering (ICDE), 2015 IEEE 31st International Conference on*, pages 1023–1034. IEEE, 2015.
- [33] H. K., J. H., C. E., W. C.L., and X. Z. Designing ssi clusters with hierarchical checkpointing and single i/o space. In *IEEE Concurrency*, 1999.
- [34] V. P. Kemerlis, G. Portokalidis, K. Jee, and A. D. Keromytis. Libdft: Practical dynamic data flow tracking for commodity systems. In *Proceedings of the 8th ACM SIGPLAN/SIGOPS Conference on Virtual Execution Environments, VEE '12*, pages 121–132, New York, NY, USA, 2012. ACM. ISBN 978-1-4503-1176-2. doi: 10.1145/2151024.2151042. URL <http://doi.acm.org/10.1145/2151024.2151042>.
- [35] L. King-Tin, S. Jinghao, H. Dominic, W. Cho-Li, L. Zhiquan, Z. Wangbin, and Y. Youliang. Rhymes: A shared virtual memory system for non-coherent tiled many-core architectures. In *ICPADS 2014*, 2014.
- [36] D. Logothetis, S. De, and K. Yocum. Scalable lineage capture for debugging disc analytics. In *Proceedings of the 4th annual Symposium on Cloud Computing*, page 17. ACM, 2013.
- [37] A. Machanavajjhala, J. Gehrke, D. Kifer, and M. Venkitasubramaniam. l-diversity: Privacy beyond k-anonymity. In *Data Engineering, 2006. ICDE'06. Proceedings of the 22nd International Conference on*, pages 24–24. IEEE, 2006.
- [38] F. McSherry. Privacy integrated queries. In *Proceedings of the 2009 ACM SIGMOD International Conference on Management of Data (SIGMOD)*. Association for Computing Machinery, Inc., June 2009. URL <https://www.microsoft.com/en-us/research/publication/privacy-integrated-queries/>.
- [39] F. McSherry and I. Mironov. Differentially private recommender systems: building privacy into the net. In *Proceedings of the 15th ACM SIGKDD international conference on Knowledge discovery and data mining*, pages 627–636. ACM, 2009.
- [40] F. McSherry and K. Talwar. Mechanism design via differential privacy. In *Proceedings of the 48th Annual IEEE Symposium on Foundations of Computer Science, FOCS '07*, pages 94–103, Washington, DC, USA, 2007. IEEE Computer Society. ISBN 0-7695-3010-9. doi: 10.1109/FOCS.2007.41. URL <http://dx.doi.org/10.1109/FOCS.2007.41>.
- [41] M. M.J.M., W. C.L., and L. F.C.M. Jessica: Java-enabled single-system-image computing architecture. In *Journal of Parallel and Distributed Computing*, 2000.
- [42] P. Mohan, A. Thakurta, E. Shi, D. Song, and D. Culler. Gupt: Privacy preserving data analysis made easy. In *Proceedings of the 2012 ACM SIGMOD International Conference on Management of Data, SIGMOD '12*, pages 349–360, New York, NY, USA, 2012. ACM. ISBN 978-1-4503-1247-9. doi: 10.1145/2213836.2213876. URL <http://doi.acm.org/10.1145/2213836.2213876>.
- [43] J. Newsome and D. Song. Dynamic taint analysis for automatic detection, analysis, and signature generation of exploits on commodity software. 2005.
- [44] O. Ohrimenko, F. Schuster, C. Fournet, A. Mehta, S. Nowozin, K. Vaswani, and M. Costa. Oblivious multi-party machine learning on trusted processors. In *25th USENIX Security Symposium (USENIX Security 16)*, pages 619–636, Austin, TX, 2016. USENIX Association. ISBN 978-1-931971-32-4. URL <https://www.usenix.org/conference/usenixsecurity16/technical-sessions/presentation/ohrimenko>.
- [45] C. Olston, B. Reed, U. Srivastava, R. Kumar, and A. Tomkins. Pig latin: a not-so-foreign language for data processing. In *Proceedings of the 2008 ACM SIGMOD international conference on Management of data*, pages 1099–1110. ACM, 2008.
- [46] P. Paillier et al. Public-key cryptosystems based on composite degree residuosity classes. In *Eurocrypt*, volume 99, pages 223–238. Springer, 1999.
- [47] A. Papadimitriou, R. Bhagwan, N. Chandran, R. Ramjee, A. Haeberlen, H. Singh, A. Modi, and S. Badrinarayanan. Big data analytics over encrypted datasets with seabed. In *OSDI*, pages 587–602, 2016.
- [48] V. Pappas, V. P. Kemerlis, A. Zavou, M. Polychronakis, and A. D. Keromytis. Cloudfence: Data flow tracking as a cloud service. In *Proceedings of the 16th International Symposium on Research in Attacks, Intrusions, and Defenses - Volume 8145, RAID 2013*, pages 411–431, New York, NY, USA, 2013. Springer-Verlag New York, Inc. ISBN 978-3-642-41283-7. doi: 10.1007/978-3-642-41284-4_21. URL http://dx.doi.org/10.1007/978-3-642-41284-4_21.
- [49] pigmix. <https://cwiki.apache.org/confluence/display/PIG/PigMix>.
- [50] R. A. Popa, C. Redfield, N. Zeldovich, and H. Balakrishnan. Cryptdb: protecting confidentiality with encrypted query processing. In *Proceedings of the Twenty-Third ACM Symposium on Operating Systems Principles*, pages 85–100. ACM, 2011.

- [51] I. Roy, S. T. V. Setty, A. Kilzer, V. Shmatikov, and E. Witchel. Airavat: Security and privacy for mapreduce. In *Proceedings of the 7th USENIX Conference on Networked Systems Design and Implementation*, NSDI'10, pages 20–20, Berkeley, CA, USA, 2010. USENIX Association. URL <http://dl.acm.org/citation.cfm?id=1855711.1855731>.
- [52] F. Schuster, M. Costa, C. Fournet, C. Gkantsidis, M. Peinado, G. Mainar-Ruiz, and M. Russinovich. Vc3: Trustworthy data analytics in the cloud using sgx. In *Security and Privacy (SP), 2015 IEEE Symposium on*, pages 38–54. IEEE, 2015.
- [53] F. Shaon, M. Kantarcioglu, Z. Lin, and L. Khan. Sgx-bigmatrix: A practical encrypted data analytic framework with trusted processors. In *Proceedings of the 17th ACM conference on Computer and communications security (CCS '10)*, 2017.
- [54] D. Sheng and W. Cho-Li. Error-tolerant resource allocation and payment minimization for cloud system. In *IEEE Transactions on Parallel and Distributed Systems (TPDS)*, 2013.
- [55] D. Sheng, R. Yves, V. Frederic, K. Derrick, W. Cho-Li, and C. Franck. Optimization of cloud task processing with checkpoint-restart mechanism. In *SC '13*, 2013.
- [56] D. Sheng, K. Derrick, and W. Cho-Li. Optimization of composite cloud service processing with virtual machines. In *IEEE Transactions on Computers*, 2014.
- [57] A. Smith. Privacy-preserving statistical estimation with optimal convergence rates. In *Proceedings of the Forty-third Annual ACM Symposium on Theory of Computing*, STOC '11, pages 813–822, New York, NY, USA, 2011. ACM. ISBN 978-1-4503-0691-1. doi: 10.1145/1993636.1993743. URL <http://doi.acm.org/10.1145/1993636.1993743>.
- [58] Spark example. <https://spark.apache.org/examples.html>.
- [59] J. J. Stephen, S. Savvides, R. Seidel, and P. Eugster. Practical confidentiality preserving big data analysis. In *6th USENIX Workshop on Hot Topics in Cloud Computing (HotCloud 14)*, Philadelphia, PA, 2014. USENIX Association. URL <https://www.usenix.org/conference/hotcloud14/workshop-program/presentation/stephen>.
- [60] L. Sweeney. k-anonymity: A model for protecting privacy. *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems*, 10(05):557–570, 2002.
- [61] Y. Tang, P. Ames, S. Bhamidipati, A. Bijlani, R. Geambasu, and N. Sarda. CleanOS: limiting mobile data exposure with idle eviction. In *Proceedings of the Tenth Symposium on Operating Systems Design and Implementation (OSDI '12)*, pages 77–91, 2012.
- [62] S. D. Tetali, M. Lesani, R. Majumdar, and T. Millstein. Mrcrypt: Static analysis for secure cloud computations. In *Proceedings of the 2013 ACM SIGPLAN International Conference on Object Oriented Programming Systems Languages & Applications, OOPSLA '13*, pages 271–286, New York, NY, USA, 2013. ACM. ISBN 978-1-4503-2374-1. doi: 10.1145/2509136.2509554. URL <http://doi.acm.org/10.1145/2509136.2509554>.
- [63] S. Tu, M. F. Kaashoek, S. Madden, and N. Zeldovich. Processing analytical queries over encrypted data. In *Proceedings of the VLDB Endowment*, volume 6, pages 289–300. VLDB Endowment, 2013.
- [64] Z. W. W. Cho-Li, , and L. F.C.M. Jessica2: A distributed java virtual machine with transparent thread migration support. In *IEEE Fourth International Conference on Cluster Computing (Cluster2002)*, 2002.
- [65] C. Wang, J. Yang, N. Yi, and H. Cui. Tripod: An efficient, highly-available cluster management system. In *Proceedings of the 7th ACM SIGOPS Asia-Pacific Workshop on Systems*, APSys '16, 2016.
- [66] C. Wang, J. Jiang, X. Chen, N. Yi, and H. Cui. Apus: Fast and scalable paxos on rdma. In *Proceedings of the Eighteenth ACM Symposium on Cloud Computing*, pages 17–28. ACM, 2017.
- [67] J. Yang, H. Cui, J. Wu, Y. Tang, and G. Hu. Determinism is not enough: Making parallel programs reliable with stable multithreading. *Communications of the ACM*, 2014.
- [68] Y. Yu, M. Isard, D. Fetterly, M. Budiu, Ú. Erlingsson, P. K. Gunda, and J. Currey. Dryadlinq: A system for general-purpose distributed data-parallel computing using a high-level language.
- [69] M. Zaharia, M. Chowdhury, T. Das, A. Dave, J. Ma, M. McCauley, M. J. Franklin, S. Shenker, and I. Stoica. Resilient distributed datasets: A fault-tolerant abstraction for in-memory cluster computing. In *Proceedings of the 9th USENIX conference on Networked Systems Design and Implementation*, pages 2–2. USENIX Association, 2012.
- [70] K. Zhang, X. Zhou, Y. Chen, X. Wang, and Y. Ruan. Sedic: privacy-aware data intensive computing on hybrid clouds. In *Proceedings of the 18th ACM conference on Computer and communications security*, pages 515–526. ACM, 2011.
- [71] W. Zheng, A. Dave, J. G. Beekman, R. A. Popa, J. E. Gonzalez, and I. Stoica. Opaque: An oblivious and encrypted distributed analytics platform. In *NSDI*, pages 283–298, 2017.
- [72] L. Zhiqun, L. King-Tin, W. Cho-Li, , and S. Jinshu. Powerock: Power modeling and flexible dynamic power management for many-core architectures. In *IEEE Systems Journal*, 2016.
- [73] T. Zhu, G. Li, W. Zhou, and S. Y. Philip. Differential privacy and applications, 2017.