## References

- [1] GitHub Azure/coco-framework. https://github.com/Azure/coco-framework.
- [2] K. A, V. P. M. Shaaban, and W. C.L. Heterogeneous computing: Challenges and opportunities. In IEEE Computer, 1993.
- [3] 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.
- [4] C. S. Alliance. Top threats to cloud computing v1.0. https://cloudsecurityalliance.org/topthreats/csathreats.v1.0.pdf, Feb. 2010.
- [5] C. S. Alliance. The notorious nine: Cloud computing top threats in 2013. https://downloads.cloudsecurityalliance.org/initiatives/top\_threats/The\_Notorious\_Nine\_Cloud\_Computing\_Top\_Threats\_in\_2013.pdf, Feb. 2013.
- [6] 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.
- [7] 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.
- [8] 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.
- [9] 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.
- [10] 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.
- [11] 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.
- [12] 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.
- [13] 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.
- [14] 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.
- [15] A. Dave and M. Zaharia. Arthur: Rich post-facto debugging for production analytics applications.
- [16] J. Dean and S. Ghemawat. Mapreduce: simplified data processing on large clusters. In OSDI'04: Proceedings of the 6th conference on Symposium on Opearting Systems Design & Implementation, pages 10–10, 2004.
- [17] C. Dwork. Differential privacy. Lecture Notes in Computer Science, 26(2):1-12, 2006.
- [18] C. Dwork. A firm foundation for private data analysis. Communications of The ACM, 54(1):86-95, 2011.
- [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] 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.
- [22] 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.
- [23] T. Frassetto, D. Gens, C. Liebchen, and A.-R. Sadeghi. Jitguard: Hardening just-in-time compilers with sgx. 2017.
- [24] 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.
- [25] C. Gentry et al. Fully homomorphic encryption using ideal lattices. In STOC, volume 9, pages 169-178, 2009.
- [26] 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.

- [27] Hadoop. Hadoop. http://hadoop.apache.org/core/.
- [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. Yuexuan, 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] S. D. I. John and A. O. Osonde. Privacy preservation in the age of big data. In RAND '16, 2016.
- [33] 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.
- [34] 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.
- [35] M. Kazim and S. Y. Zhu. A survey on top security threats in cloud computing. International Journal of Advanced Computer Science and Applications (IJACSA), 2015.
- [36] 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.
- [37] 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.
- [38] 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.
- [39] 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.
- [40] G. Malewicz, M. H. Austern, A. J. Bik, J. C. Dehnert, I. Horn, N. Leiser, and G. Czajkowski. Pregel: a system for large-scale graph processing. In *Proceedings of the 2010 ACM SIGMOD International Conference on Management of data*, pages 135–146. ACM, 2010.
- [41] 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/.
- [42] 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.
- [43] 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.
- [44] L. Nelson, H. Sigurbjarnarson, K. Zhang, D. Johnson, J. Bornholt, E. Torlak, and X. Wang. Hyperkernel: Push-button verification of an os kernel. In *Proceedings of the 26th Symposium on Operating Systems Principles (SOSP '17)*.
- [45] J. Newsome and D. Song. Dynamic taint analysis for automatic detection, analysis, and signature generation of exploits on commodity software. 2005.
- [46] 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.
- [47] 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.
- [48] P. Paillier et al. Public-key cryptosystems based on composite degree residuosity classes. In Eurocrypt, volume 99, pages 223–238. Springer, 1999.
- [49] 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.
- [50] 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.
- [51] pigmix. https://cwiki.apache.org/confluence/display/PIG/PigMix.

- [52] 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.
- [53] 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.
- [54] 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.
- [55] 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.
- [56] 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.
- [57] 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.
- [58] D. Sheng, K. Derrick, and W. Cho-Li. Optimization of composite cloud service processing with virtual machines. In IEEE Transactions on Computers, 2014.
- [59] A. Smith. Efficient, differentially private point estimators. arXiv preprint arXiv:0809.4794, 2008.
- [60] 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.
- [61] Spark example. https://spark.apache.org/examples.html.
- [62] 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.
- [63] L. Sweeney. k-anonymity: A model for protecting privacy. International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, 10(05):557–570, 2002.
- [64] S. Technology. 7 most infamous cloud security breaches. https://www.storagecraft.com/blog/7-infamous-cloud-security-breaches/, Feb. 2017.
- [65] 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.
- [66] C.-C. Tsai, D. E. Porter, and M. Vij. Graphene-sgx: A practical library os for unmodified applications on sgx. In 2017 USENIX Annual Technical Conference (USENIX ATC), 2017.
- [67] 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.
- [68] 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.
- [69] 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.
- [70] 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.
- [71] N. World. Leaked icloud credentials obtained from third parties, apple says. https://www.networkworld.com/article/3184471/security/leaked-icloud-credentials-obtained-from-third-parties-apple-says.html, Feb. 2017.
- [72] 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.
- [73] 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.
- [74] 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.
- [75] 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.
- [76] 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.
- [77] L. Zhiquan, 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.