

References

- [1] GitHub - Azure/coco-framework. <https://github.com/Azure/coco-framework>.
- [2] CVE-2017-7533. <http://seclists.org/oss-sec/2017/q3/240>.
- [3] CVE-2017-12193. <https://access.redhat.com/security/cve/cve-2017-12193>.
- [4] K. A. V. P. M. Shaaban, and W. C.L. Heterogeneous computing: Challenges and opportunities. In *IEEE Computer*, 1993.
- [5] F. Adelstein, M. Stillerman, and D. Kozen. Malicious code detection for open firmware. In *Computer Security Applications Conference, 2002. Proceedings. 18th Annual*, pages 403–412. IEEE, 2002.
- [6] 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>.
- [7] C. S. Alliance. Top threats to cloud computing v1.0. <https://cloudsecurityalliance.org/topthreats/csathreats.v1.0.pdf>, Feb. 2010.
- [8] 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.
- [9] S. Bajaj and R. Sion. Trustdddb: 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>.
- [10] 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>.
- [11] 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.
- [12] 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.
- [13] 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.
- [14] 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.
- [15] H. Cui, G. Hu, J. Wu, and J. Yang. Verifying systems rules using rule-directed symbolic execution. In *Eighteenth International Conference on Architecture Support for Programming Languages and Operating Systems (ASPLOS ’13)*, 2013.
- [16] 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.
- [17] 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.
- [18] A. Dave and M. Zaharia. Arthur: Rich post-facto debugging for production analytics applications.
- [19] 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.
- [20] C. Dwork. Differential privacy. *Lecture Notes in Computer Science*, 26(2):1–12, 2006.
- [21] 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.
- [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] Hadoop. Hadoop. <http://hadoop.apache.org/core/>.
- [29] 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.
- [30] Intel. Software guard extensions programming reference. <https://software.intel.com/sites/default/files/329298-001.pdf>.
- [31] 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>.
- [32] 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.
- [33] S. D. I. John and A. O. Osonde. Privacy preservation in the age of big data. In *RAND '16*, 2016.
- [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. Zhiqian, Z. Wangbin, and Y. Youliang. Rhymes: A shared virtual memory system for non-coherent tiled many-core architectures. In *ICPADS 2014*, 2014.
- [38] Z. Lai, K. T. Lam, C.-L. Wang, J. Su, Y. Yan, and W. Zhu. Latency-aware dynamic voltage and frequency scaling on many-core architectures for data-intensive applications. In *Cloud Computing and Big Data (CloudCom-Asia), 2013 International Conference on*, pages 78–83. IEEE, 2013.
- [39] 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.
- [40] T. Ma, L. Chen, C.-L. Wang, and F. C. Lau. G-pass: An instance-oriented security infrastructure for grid travelers. In *Computation and Currency: Practice and Experience*. IEEE, 2006.
- [41] 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.
- [42] 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.
- [43] 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/>.
- [44] 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.
- [45] 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>.
- [46] 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)*.
- [47] 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>.
- [48] 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.
- [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] L. Sweeney. k-anonymity: A model for protecting privacy. *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems*, 10(05):557–570, 2002.
- [63] F. Tang, M. Guo, M. Li, C.-L. Wang, and M. Dong. Secure routing for wireless mesh sensor networks in pervasive environments. In *INTERNATIONAL JOURNAL OF INTELLIGENT CONTROL AND SYSTEMS*. IEEE, 2007.
- [64] S. Technology. 7 most infamous cloud security breaches. <https://www.storagecraft.com/blog/7-infamous-cloud-security-breaches/>, Feb. 2017.
- [65] 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.
- [66] 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.
- [67] 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.
- [68] B. Wang, B. Li, and H. Li. Panda: Public auditing for shared data with efficient user revocation in the cloud. *IEEE Transactions on services computing*, 8(1):92–106, 2015.
- [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] Y. Wang, J. Wei, M. Srivatsa, Y. Duan, and W. Du. Integritymr: Integrity assurance framework for big data analytics and management applications. In *Big Data, 2013 IEEE International Conference on*, pages 33–40. IEEE, 2013.
- [72] 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.
- [73] J. Wu, Y. Tang, G. Hu, H. Cui, and J. Yang. Sound and precise analysis of parallel programs through schedule specialization. In *Proceedings of the ACM SIGPLAN 2012 Conference on Programming Language Design and Implementation (PLDI ’12)*, pages 205–216, June 2012.
- [74] 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.
- [75] 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.
- [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.