References

[1] R. Bolla, R. Bruschi, F. Davoli, and F. Cucchietti, "Energy Efficiency in the Future Internet: A Survey of Existing Approaches and Trends in Energy-Aware Fixed Network Infrastructures," *IEEE Communications Surveys Tutorials*, vol. 13, no. 2, pp. 223–244, 2011, ISSN: 1553-877X. DOI: 10.1109/SURV.2011.071410.00073.

[2] F. Idzikowski, L. Chiaraviglio, A. Cianfrani, J. López Vizcaíno, M. Polverini, and Y. Ye, "A Survey on Energy-Aware Design and Operation of Core Networks," *IEEE Communications Surveys Tutorials*, vol. 18, no. 2, pp. 1453–1499, 2016, ISSN: 1553-877X. DOI: 10.1109/COMST.2015.2507789.

[3] R. Maaloul, L. Chaari, and B. Cousin, "Energy saving in carrier-grade networks: A survey," *Computer Standards & Interfaces*, vol. 55, pp. 8–26, January 1, 2018, ISSN: 0920-5489. DOI: 10.1016/j.csi.2017.04.001. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0920548916301817 (visited on 07/26/2020).

[4] P. Delforge and J. Whitney, "Data center efficiency assessment - scaling up energy efficiency across the data center industry: Evaluating key drivers and barriers," Natural Resources Defense Council, IP:14.08-A, August 2014. [Online]. Available: https://www.nrdc.org/sites/default/files/data-center-efficiency-assessment-IP.pdf (visited on 10/03/2020).

[5] "Cisco visual networking index: Forecast and methodology, 2014–2019," Cisco Systems, San Jose, CA, 2015.

[6] "Cisco visual networking index: Forecast and methodoolgy, 2015-2020," Cisco Systems, San Jose, CA, 2016.

[7] "Cisco visual networking index: Forecast and methodology, 2016–2021," Cisco Systems, San Jose, CA, 2017.

[8] "Cisco Visual Networking Index: Forecast and Trends, 2017-2022," Cisco Systems, San Jose, CA, 2019.

[9] K. Ishii, J. Kurumida, K.-i. Sato, T. Kudoh, and S. Namiki, "Unifying Top-Down and Bottom-Up Approaches to Evaluate Network Energy Consumption," *Journal of Lightwave Technology*, vol. 33, no. 21, pp. 4395–4405, November 2015, ISSN: 1558-2213. DOI: 10.1109/JLT.2015.2469145.

[10] "Metro network traffic growth: An architecture impact study," Alcatel-Lucent, 2013.

[11] W. B. Norton, *The 2014 Internet Peering Playbook: Connecting to the Core of the Internet*. DrPeering Press, January 1, 2014, 440 pp.

[12] "Global Internet Phenomena Report," Sandvine, 2013. [Online]. Available: https://www.sandvine.com/hubfs/downloads/archive/2013-2h-global-internet-phenomena-report.pdf (visited on 07/04/2020).

[13] "Global Internet Phenomena - Africa, Middle East & North America," December 2015. [Online]. Available: https://www.sandvine.com/hubfs/downloads/archive/2015-global-internet-phenomena-report-africa-middle-east-and-north-america.pdf (visited on 07/04/2020).

[14] "Global Internet Phenomena Report," Sandvine, Sep. 2019.

[15] U. Lee, I. Rimac, and V. Hilt, "Greening the internet with content-centric networking," in *Proceedings of the 1st International Conference on Energy-Efficient Computing and Networking*, ser. E-Energy '10, Passau, Germany: Association for Computing Machinery, April 13, 2010, pp. 179–182, ISBN: 978-1-4503-0042-1. DOI: 10.1145/1791314.1791342. [Online]. Available: https://doi.org/10.1145/1791314.1791342 (visited on 07/04/2020).

[16] K. Guan, G. Atkinson, D. C. Kilper, and E. Gulsen, "On the Energy Efficiency of Content Delivery Architectures," in *2011 IEEE International Conference on Communications Workshops (ICC)*, Jun. 2011, pp. 1–6. DOI: 10.1109/iccw.2011.5963557.

[17] N. Choi, K. Guan, D. C. Kilper, and G. Atkinson, "In-network caching effect on optimal energy consumption in content-centric networking," in *2012 IEEE International Conference on Communications (ICC)*, Jun. 2012, pp. 2889–2894. DOI: 10.1109/ICC.2012.6364320.

[18] N. I. Osman, T. El-Gorashi, and J. M. H. Elmirghani, "Reduction of energy consumption of Video-on-Demand services using cache size optimization," in *2011 Eighth International Conference on Wireless and Optical Communications Networks*, May 2011, pp. 1–5. DOI: 10.1109/WOCN.2011.5872923.

[19] J. Llorca, A. M. Tulino, K. Guan, J. Esteban, M. Varvello, N. Choi, and D. C. Kilper, "Dynamic in-network caching for energy efficient content delivery," in *2013 Proceedings IEEE INFOCOM*, April 2013, pp. 245–249. DOI: 10.1109/INFCOM.2013.6566772.

[20] U. Mandal, P. Chowdhury, C. Lange, A. Gladisch, and B. Mukherjee, "Energy-efficient networking for content distribution over telecom network infrastructure," *Optical Switching and Networking*, vol. 10, no. 4, pp. 393–405, November 1, 2013, ISSN: 1573-4277. DOI: 10.1016/j.osn.2013.06.003. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S1573427713000428 (visited on 07/04/2020).

[21] R. Modrzejewski, L. Chiaraviglio, I. Tahiri, F. Giroire, E. Le Rouzic, E. Bonetto, F. Musumeci, R. Gonzalez, and C. Guerrero, "Energy efficient content distribution in an ISP network," in *2013 IEEE Global Communications Conference (GLOBECOM)*, December 2013, pp. 2859–2865. DOI: 10.1109/GLOCOM.2013.6831508.

[22] N. Abji, A. Tizghadam, and A. Leon-Garcia, "Energy efficient content delivery in service provider networks with content caching," in *2015 IEEE Online Conference on Green Communications (OnlineGreenComm)*, November 2015, pp. 23–29. DOI: 10.1109/OnlineGreenCom.2015.7387374.

[23] M. Savi, O. Ayoub, F. Musumeci, Z. Li, G. Verticale, and M. Tornatore, "Energy-efficient caching for Video-on-Demand in Fixed-Mobile Convergent networks," in *2015 IEEE Online Conference on Green Communications (OnlineGreenComm)*, November 2015, pp. 17–22. DOI: 10.1109/OnlineGreenCom.2015.7387373.

[24] C. Jayasundara, A. Nirmalathas, E. Wong, and C. Chan, "Improving Energy Efficiency of Video on Demand Services," *IEEE/OSA Journal of Optical Communications and Networking*, vol. 3, no. 11, pp. 870–880, November 2011, ISSN: 1943-0639. DOI: 10.1364/JOCN.3.000870.

[25] R. Fratini, M. Savi, G. Verticale, and M. Tornatore, "Using replicated video servers for VoD traffic offloading in integrated metro/access networks," in *2014 IEEE International Conference on Communications (ICC)*, Jun. 2014, pp. 3438–3443. DOI: 10.1109/ICC.2014.6883853.

[26] E. D. Pascale, D. B. Payne, and M. Ruffini, "Bandwidth and energy savings of locality-aware P2P Content Distribution in next-generation PONs," in *2012 16th International Conference on Optical Network Design and Modelling (ONDM)*, April 2012, pp. 1–6. DOI: 10.1109/ONDM.2012.6210215.

[27] *Y.3001 : Future networks: Objectives and design goals*, May 20, 2011. [Online]. Available: https://www.itu.int/rec/T-REC-Y.3001-201105-I.

[28] "Pervasive Mobile Virtual Services," Expert Advisory Group of the European Technology Platform Networld 2020, Jul. 2016. [Online]. Available: https://www.networld2020.eu/wp-content/uploads/2014/02/SRIA_final.pdf.

[29] C. Bouchat, M. Paul, D. Allan, and G. Dalle, "5G Wireless Wireline Convergence Atchitecture," Broadband Forum, TR-470, August 2020. [Online]. Available: https://www.broadband-forum.org/technical/download/TR-470.pdf (visited on 10/03/2020).

[30] "Environmental Engineering (EE); Green Abstraction Layer (GAL); Power management capabilities of the future energy telecommunication fixed network nodes," ETSI Standard ETSI ES 203 237 V1.1.1, March 2014, pp. 1–34.

[31] R. Bolla, R. Bruschi, F. Davoli, C. Lombardo, J. F. Pajo, and O. R. Sanchez, "The dark side of network functions virtualization: A perspective on the technological sustainability," in *IEEE International Conference on Communications (ICC)*, May 2017, pp. 1–7. DOI: 10.1109/ICC.2017.7997129.

[32] "Network Functions Virtualisation (NFV); Use Cases," ETSI, RGR/NFV-001ed121, May 1, 2017.

[33] W. Shi, "Making sense of the telco cloud," Telecoms.com, May 29, 2020, p. 12. [Online]. Available: https://telecoms.com/opinion/making-sense-of-the-telco-cloud/ (visited on 06/27/2020).

[34] "Edge computing and deployment strategies for communication service providers," Ericsson, GFMC-20:000097, February 1, 2020, p. 13. [Online]. Available: https://www.ericsson.com/en/reports-and-papers/white-papers/edge-computing-and-deployment-strategies-for-communication-service-providers (visited on 06/28/2020).

[35] J. Crawshaw. (). Deconstructing the Telco Cloud, Light Reading, [Online]. Available: https://www.lightreading.com/cloud/deconstructing-the-telco-cloud/a/d-id/753874 (visited on 07/25/2020).

[36] S. E. E. Ayoubi, S. Jeux, F. Marache, F. Pujol, M. Fallgren, P. Spapis, C. Yang, A. Widaa, J. Markendahl, A. Ghanbari, R. Ruismaki, M. Uusitalo, W. Koenig, A. Trogolo, I. Korthals, T. Rosowski, G. Zimmermann, L. Campoy, J. Monserrat, D. Martin-Sacristan, H. Schotten, Y. Qi, S. Singh, and P. Agyapong, "Refined scenarios and requirements, consolidated use cases, and qualitative techno-economic feasibility assessment," D1.1, January 31, 2016. [Online]. Available: https://metis-ii.5g-ppp.eu/wp-content/uploads/deliverables/METIS-II_D1.1_v1.0.pdf (visited on 06/29/2020).

[37] J. Muthurajan, "Why Use Cloud-Native Containerized Network Functions (CNFs)?" Intel, White paper. [Online]. Available: https://www.intel.com/content/www/uk/en/communications/why-containers-and-cloud-native-functions-paper.html (visited on 07/25/2020).

[38] R. Vettor and S. Ardalis Smith. (October 11, 2020). Architecting Cloud Native .NET Applications for Azure, [Online]. Available: https://docs.microsoft.com/en-us/dotnet/architecture/cloud-native/.

[39] M. Logan. (). CNCF F Technical Oversight Committee (TOOC), GitHub, [Online]. Available: https://github.com/cncf/toc (visited on 07/25/2020).

[40] (2021). DPDK. in collab. with linuxfoundation, DPDK, [Online]. Available: https://www.dpdk.org/ (visited on 02/25/2021).

[41] M. Dayarathna, Y. Wen, and R. Fan, "Data Center Energy Consumption Modeling: A Survey," *IEEE Communications Surveys Tutorials*, vol. 18, no. 1, pp. 732–794, 2016, ISSN: 1553-877X. DOI: 10.1109/COMST.2015.2481183.

[42] G. D. Costa, J.-M. Pierson, and L. Fontoura-Cupertino, "Effectiveness of Neural Networks for Power Modeling for Cloud and HPC: It's Worth It!" *ACM Transactions on Modeling and Performance Evaluation of Computing Systems*, vol. 5, no. 3, pp. 1–36, October 19, 2020, ISSN: 2376-3639, 2376-3647. DOI: 10.1145/3388322. [Online]. Available: https://dl.acm.org/doi/10.1145/3388322 (visited on 10/25/2020).

[43] L. Ismail and H. Materwala, "Computing Server Power Modeling in a Data Center: Survey, Taxonomy, and Performance Evaluation," *ACM Computing Surveys*, vol. 53, no. 3, pp. 1–34, Jul. 5, 2020, ISSN: 0360-0300, 1557-7341. DOI: 10.1145/3390605. [Online]. Available: https://dl.acm.org/doi/10.1145/3390605 (visited on 07/07/2020).

[44] W. Lin, F. Shi, W. Wu, K. Li, G. Wu, and A.-A. Mohammed, "A Taxonomy and Survey of Power Models and Power Modeling for Cloud Servers," *ACM Computing Surveys*, vol. 53, no. 5, 100:1–100:41, Sep. 28, 2020, ISSN: 0360-0300. DOI: 10.1145/3406208. [Online]. Available: https://doi.org/10.1145/3406208 (visited on 10/24/2020).

[45] R. E. Boyatzis, *Transforming Qualitative Information: Thematic Analysis and Code Development*, ser. Transforming Qualitative Information: Thematic Analysis and Code Development. Thousand Oaks, CA, US: Sage Publications, Inc, 1998, pp. xvi, 184, xvi, 184.

[46] V. Braun and Victoria Clarke, "Using thematic analysis in psychology," *Qualitative Research in Psychology*, vol. 3, no. 2, pp. 77–101, 2006. DOI: 10.1191/1478088706qp063oa. [Online]. Available: https://www.tandfonline.com/doi/abs/10.1191/1478088706qp063oa.

[47] J. W. Creswell and C. N. Poth, *Qualitative Inquiry and Research Design: Choosing among Five Approaches*. Sage publications, 2016.

[48] J. Saldana, "An introduction to codes and coding," in *The Coding Manual for Qualitative Researchers*, 1st, California: Sage Publications, Inc, 2009, ISBN: 978-1-84787-549-5.

[49] B. Knowles, L. Blair, M. Hazas, and S. Walker, "Exploring sustainability research in computing: Where we are and where we go next," in *Proceedings of the 2013 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, ser. UbiComp '13, New York, NY, USA: Association for Computing Machinery, Sep. 8, 2013, pp. 305–314, ISBN: 978-1-4503-1770-2. DOI: 10.1145/2493432.2493474. [Online]. Available: https://doi.org/10.1145/2493432.2493474 (visited on 02/04/2021).

[50] W. Ye, N. Vijaykrishnan, M. Kandemir, and M. J. Irwin, "The design and use of simplepower: A cycle-accurate energy estimation tool," in *37th Conference on Design Automation - DAC '00*, Los Angeles, California, United States: ACM Press, 2000, pp. 340–345, ISBN: 978-1-58113-187-1. DOI: 10.1145/337292.337436. [Online]. Available: http://portal.acm.org/citation.cfm?doid=337292.337436 (visited on 12/18/2019).

[51] D. Brooks, V. Tiwari, and M. Martonosi, "Wattch: A framework for architectural-level power analysis and optimizations," in *27th International Symposium on Computer Architecture (IEEE Cat. No.RS00201)*, Jun. 2000, pp. 83–94.

[52] X. Fan, W.-D. Weber, and L. A. Barroso, "Power provisioning for a warehouse-sized computer," *ACM SIGARCH Computer Architecture News*, vol. 35, no. 2, pp. 13–23, Jun. 9, 2007, ISSN: 0163-5964. DOI: 10.1145/1273440.1250665. [Online]. Available: https://doi.org/10.1145/1273440.1250665 (visited on 10/05/2020).

[53] A. Vasan, A. Sivasubramaniam, V. Shimpi, T. Sivabalan, and R. Subbiah, "Worth their watts? - an empirical study of datacenter servers," in *HPCA - 16 2010 The Sixteenth International Symposium on High-Performance Computer Architecture*, January 2010, pp. 1–10. DOI: 10.1109/HPCA.2010.5463056.

[54] M. Aldossary, I. Alzamil, and K. Djemame, "Towards Virtual Machine Energy-Aware Cost Prediction in Clouds," in *Economics of Grids, Clouds, Systems, and Services*, C. Pham, J. Altmann, and J. Á. Bañares, Eds., ser. Lecture Notes in Computer Science, Cham: Springer International Publishing, 2017, pp. 119–131, ISBN: 978-3-319-68066-8. DOI: 10.1007/978-3-319-68066-8_10.

[55] F. Bellosa, "The benefits of event: Driven energy accounting in power-sensitive systems," in *Proceedings of the 9th Workshop on ACM SIGOPS European Workshop beyond the PC: New Challenges for the Operating System - EW 9*, Kolding, Denmark: ACM Press, 2000, p. 37. DOI: 10.1145/566726.566736.

[56] C. Isci and M. Martonosi, "Runtime power monitoring in high-end processors: Methodology and empirical data," in *Proceedings. 36th Annual IEEE/ACM International Symposium on Microarchitecture, 2003. MICRO-36.*, December 2003, pp. 93–104. DOI: 10.1109/MICRO.2003.1253186.

[57] J. Laurent, N. Julien, E. Senn, and E. Martin, "Functional level power analysis: An efficient approach for modeling the power consumption of complex processors," in *Automation and Test in Europe Conference and Exhibition Proceedings Design*, vol. 1, February 2004, 666–667 Vol.1. DOI: 10.1109/DATE.2004.1268921.

[58] S. K. Rethinagiri, O. Palomar, J. A. Moreno, O. Unsal, and A. Cristal, "VPM: Virtual power meter tool for low-power many-core/heterogeneous data center prototypes," in *2015 33rd IEEE International Conference on Computer Design (ICCD)*, October 2015, pp. 651–658. DOI: 10.1109/ICCD.2015.7357177.

[59] R. Bertran, M. Gonzàlez, X. Martorell, N. Navarro, and E. Ayguadé, "Counter-based power modeling methods: Top-down vs. bottom-up," *The Computer Journal*, vol. 56, no. 2, pp. 198–213, 2013.

[60] W. L. Bircher, M. Valluri, J. Law, and L. K. John, "Runtime identification of microprocessor energy saving opportunities," in *Proceedings of the 2005 International Symposium on Low Power Electronics and Design.*, August 2005, pp. 275–280. DOI: 10.1145/1077603.1077668.

[61] N. Khan, "Investigating Energy Efficiency of Physical and Virtual Machines in Cloud Computing," Univeristy of Oslo, 2017. [Online]. Available: https://www.duo.uio.no/handle/10852/61321 (visited on 11/07/2019).

[62] Q. Chen, P. Grosso, K. van der Veldt, C. de Laat, R. Hofman, and H. Bal, "Profiling Energy Consumption of VMs for Green Cloud Computing," in *2011 IEEE Ninth International Conference on Dependable, Autonomic and Secure Computing*, Sydney, Australia: IEEE, December 2011, pp. 768–775. DOI: 10.1109/DASC.2011.131. [Online]. Available: http://ieeexplore.ieee.org/document/6118905/ (visited on 02/18/2021).

[63] R. Morabito, "Power Consumption of Virtualization Technologies: An Empirical Investigation," in *2015 IEEE/ACM 8th International Conference on Utility and Cloud Computing (UCC)*, December 2015, pp. 522–527. DOI: 10.1109/UCC.2015.93.

[64] R. Shea, H. Wang, and J. Liu, "Power consumption of virtual machines with network transactions: Measurement and improvements," in *IEEE INFOCOM 2014 - IEEE Conference on Computer Communications*, April 2014, pp. 1051–1059. DOI: 10.1109/INFOCOM.2014.6848035.

[65] Y. Hu and T. Li, "Towards efficient server architecture for virtualized network function deployment: Implications and implementations," in *2016 49th Annual IEEE/ACM International Symposium on Microarchitecture (MICRO)*, October 2016, pp. 1–12. DOI: 10.1109/MICRO.2016.7783711.

[66] Z. Xu, F. Liu, T. Wang, and H. Xu, "Demystifying the energy efficiency of Network Function Virtualization," in *2016 IEEE/ACM 24th International Symposium on Quality of Service (IWQoS)*, Jun. 2016, pp. 1–10. DOI: 10.1109/IWQoS.2016.7590429.

[67] S. Fu, J. Liu, and W. Zhu, "Multimedia Content Delivery with Network Function Virtualization: The Energy Perspective," *IEEE MultiMedia*, vol. 24, no. 3, pp. 38–47, 2017, ISSN: 1941-0166. DOI: 10.1109/MMUL.2017.3051514.

[68] X. Li, W. Cheng, T. Zhang, F. Ren, and B. Yang, "Towards Power Efficient High Performance Packet I/O," *IEEE Transactions on Parallel and Distributed Systems*, vol. 31, no. 4, pp. 981–996, April 2020, ISSN: 1558-2183. DOI: 10.1109/TPDS.2019.2957746.

[69] *CNF friendly networking for Telco/Edge Kubernetes platforms*, in collab. with S. Addepalli and S. Vallala, Sep. 24, 2020. [Online]. Available: https://www.brighttalk.com/webcast/12229/438035/cnf-friendly-networking-for-telco-edge-kubernetes-platforms (visited on 09/28/2020).

[70] G. Li, D. Zhang, Y. Li, and K. Li, "Toward energy-efficiency optimization of pktgen-DPDK for green network testbeds," *China Communications*, vol. 15, no. 11, pp. 199–207, November 2018, ISSN: 1673-5447. DOI: 10.1109/CC.2018.8543100.

[71] (). Intel® Ethernet Server Adapter I350: Product Brief, Intel, [Online]. Available: https://www.intel.com/content/www/us/en/products/docs/network-io/ethernet/10-25-40-gigabit-adapters/ethernet-i350-server-adapter-brief.html (visited on 02/09/2021).

[72] Z. Zhang and S. Fu, "Macropower: A coarse-grain power profiling framework for energy-efficient cloud computing," in *30th IEEE International Performance Computing and Communications Conference*, November 2011, pp. 1–8. DOI: 10.1109/PCCC.2011.6108061.

[73] (2021). KVM. in collab. with L. Foundation, [Online]. Available: https://www.linux-kvm.org/page/Main_Page (visited on 03/02/2021).

[74] M. Aldossary, K. Djemame, I. Alzamil, A. Kostopoulos, A. Dimakis, and E. Agiatzidou, "Energy-aware cost prediction and pricing of virtual machines in cloud computing environments," *Future Generation Computer Systems*, vol. 93, pp. 442–459, April 1, 2019, ISSN: 0167-739X. DOI: 10.1016/j.future.2018.10.027. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0167739X18310288 (visited on 07/23/2020).

[75] Y. Li, Y. Wang, B. Yin, and L. Guan, "An Online Power Metering Model for Cloud Environment," in *2012 IEEE 11th International Symposium on Network Computing and Applications*, Cambridge, MA, August 2012, pp. 175–180. DOI: 10.1109/NCA.2012.10.

[76] C. Wen, X. Long, Y. Yang, F. Ni, and Y. Mu, "System Power Model and Virtual Machine Power Metering for Cloud Computing Pricing," in *2013 Third International Conference on Intelligent System Design and Engineering Applications*, January 2013, pp. 1379–1382. DOI: 10.1109/ISDEA.2012.327.

[77] P. Arroba, J. L. Risco-Martín, M. Zapater, J. M. Moya, J. L. Ayala, and K. Olcoz, "Server Power Modeling for Run-time Energy Optimization of Cloud Computing Facilities," *Energy Procedia*, 6th International Conference on Sustainability in Energy and Buildings, SEB-14, vol. 62, pp. 401–410, January 1, 2014, ISSN: 1876-6102. DOI: 10.1016/j.egypro.2014.12.402. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S187661021403433X (visited on 12/17/2019).

[78] W. Wu, W. Lin, and Z. Peng, "An intelligent power consumption model for virtual machines under CPU-intensive workload in cloud environment," *Soft Computing*, vol. 21, no. 19, pp. 5755–5764, October 2017, ISSN: 1432-7643, 1433-7479. DOI: 10.1007/s00500-016-2154-6.

[79] G. Dhiman, K. Mihic, and T. Rosing, "A system for online power prediction in virtualized environments using Gaussian mixture models," in *Proceedings of the 47th Design Automation Conference*, Anaheim, CA: ACM Press, Jun. 2010, p. 807, ISBN: 978-1-4503-0002-5. DOI: 10.1145/1837274.1837478.

[80] H. A. Salam, F. Davoli, and A. Timm-Giel, "Improving Prediction Accuracy for Power Consumption in Virtual Environments," in *2019 29th International Telecommunication Networks and Applications Conference (ITNAC)*, November 2019, pp. 1–6. DOI: 10.1109/ITNAC46935.2019.9077952.

[81] H. A. Salam, F. Davoli, A. Carrega, and A. Timm-Giel, "Towards Prediction of Power Consumption of Virtual Machines for Varying Loads," in *2018 28th International Telecommunication Networks and Applications Conference (ITNAC)*, November 2018, pp. 1–6. DOI: 10.1109/ATNAC.2018.8615319.

[82] M. Callau-Zori, L. Samoila, A.-C. Orgerie, and G. Pierre, "An experiment-driven energy consumption model for virtual machine management systems," *Sustainable Computing: Informatics and Systems*, vol. 18, pp. 163–174, Jun. 2018, ISSN: 22105379. DOI: 10.1016/j.suscom.2017.11.001.

[83] S. Chinprasertsuk and S. Gertphol, "Power model for virtual machine in cloud computing," in *2014 11th International Joint Conference on Computer Science and Software Engineering (JCSSE)*, May 2014, pp. 140–145. DOI: 10.1109/JCSSE.2014.6841857.

[84] T. Enokido and M. Takizawa, "The Extended Power Consumption Model to Perform Computation Type Application Processes on Virtual Machines," in *2016 10th International Conference on Complex, Intelligent, and Software Intensive Systems (CISIS)*, Fukuoka, Japan: IEEE, Jul. 2016, pp. 15–22, ISBN: 978-1-5090-0987-9. DOI: 10.1109/CISIS.2016.82. [Online]. Available: http://ieeexplore.ieee.org/document/7791857/ (visited on 12/18/2019).

[85] ——, "Power Consumption Model of a Server to Perform Communication Type Application Processes on Virtual Machines," in *2015 10th International Conference on Broadband and Wireless Computing, Communication and Applications (BWCCA)*, November 2015, pp. 275–282. DOI: 10.1109/BWCCA.2015.67.

[86] B. Krishnan, H. Amur, A. Gavrilovska, and K. Schwan, "VM power metering: Feasibility and challenges," *ACM SIGMETRICS Performance Evaluation Review*, vol. 38, no. 3, p. 56, January 3, 2011, ISSN: 01635999. DOI: 10.1145/1925019.1925031.

[87] T. Enokido and M. Takizawa, "Power Consumption and Computation Models of Virtual Machines to Perform Computation Type Application Processes," in *2015 Ninth International Conference on Complex, Intelligent, and Software Intensive Systems*, Jul. 2015, pp. 126–133. DOI: 10.1109/CISIS.2015.18.

[88] M. Aldossary and K. Djemame, "Performance and Energy-based Cost Prediction of Virtual Machines Live Migration in Clouds:" in *Proceedings of the 8th International Conference on Cloud Computing and Services Science*, Funchal, Madeira, Portugal: SCITEPRESS - Science and Technology Publications, 2018, pp. 384–391, ISBN: 978-989-758-295-0. DOI: 10

.5220/0006682803840391. [Online]. Available: http://www.scitepress.org/DigitalLibrary/Link.aspx?doi=10.5220/0006682803840391 (visited on 07/23/2020).

[89] ——, "Energy-based Cost Model of Virtual Machines in a Cloud Environment," in *2018 Fifth International Symposium on Innovation in Information and Communication Technology (ISIICT)*, October 2018, pp. 1–8. DOI: 10.1109/ISIICT.2018.8613288.

[90] I. Alzamil and K. Djemame, "Energy Prediction for Cloud Workload Patterns," in *Economics of Grids, Clouds, Systems, and Services*, J. Á. Bañares, K. Tserpes, and J. Altmann, Eds., ser. Lecture Notes in Computer Science, Cham: Springer International Publishing, 2017, pp. 160–174, ISBN: 978-3-319-61920-0. DOI: 10.1007/978-3-319-61920-0_12.

[91] A. Kansal, F. Zhao, J. Liu, N. Kothari, and A. A. Bhattacharya, "Virtual machine power metering and provisioning," in *Proceedings of the 1st ACM Symposium on Cloud Computing - SoCC '10*, Indianapolis, Indiana, USA: ACM Press, 2010, p. 39, ISBN: 978-1-4503-0036-0. DOI: 10.1145/1807128.1807136. [Online]. Available: http://portal.acm.org/citation.cfm?doid=1807128.1807136 (visited on 07/23/2020).

[92] I. Waßmann, D. Versick, and D. Tavangarian, "Energy consumption estimation of virtual machines," in *Proceedings of the 28th Annual ACM Symposium on Applied Computing*, ser. SAC '13, Coimbra, Portugal: Association for Computing Machinery, March 18, 2013, pp. 1151–1156, ISBN: 978-1-4503-1656-9. DOI: 10.1145/2480362.2480579. [Online]. Available: https://doi.org/10.1145/2480362.2480579 (visited on 07/23/2020).

[93] C. Gu, P. Shi, S. Shi, H. Huang, and X. Jia, "A Tree Regression Based Approach for VM Power Metering," *IEEE Access*, vol. 3, pp. 1–1, January 1, 2015. DOI: 10.1109/ACCESS.2015.2430276.

[94] W. Silva-de-Souza, A. Iranfar, A. Bráulio, M. Zapater, S. Xavier-de-Souza, K. Olcoz, and D. Atienza, "Containergy—A Container-Based Energy and Performance Profiling Tool for Next Generation Workloads," *Energies*, vol. 13, no. 9, p. 2162, May 1, 2020, ISSN: 1996-1073. DOI: 10.3390/en13092162. [Online]. Available: https://www.mdpi.com/1996-1073/13/9/2162 (visited on 10/25/2020).

[95] T. Veni and S. M. S. Bhanu, "Prediction Model for Virtual Machine Power Consumption in Cloud Environments," *Procedia Computer Science*, vol. 87, pp. 122–127, 2016, ISSN: 18770509. DOI: 10.1016/j.procs.2016.05.137.

[96] (December 11, 2020). SPEC Benchmarks, [Online]. Available: https://www.spec.org/benchmarks.html.

[97] J. Phung, C. L. Young, and A. Y. Zomaya, "Application-Agnostic Power Monitoring in Virtualized Environments," in *2017 17th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGRID)*, May 2017, pp. 335–344. DOI: 10.1109/CCGRID.2017.100.

[98] J. Phung, Y. C. Lee, and A. Y. Zomaya, "Lightweight Power Monitoring Framework for Virtualized Computing Environments," *IEEE Transactions on Computers*, vol. 69, no. 1, pp. 14–25, January 2020, ISSN: 1557-9956. DOI: 10.1109/TC.2019.2936018.

[99] R. Bolla, R. Bruschi, F. Davoli, and J. F. Pajo, "A Model-Based Approach Towards Real-Time Analytics in NFV Infrastructures," *IEEE Transactions on Green Communications and Networking*, vol. 4, no. 2, pp. 529–541, Jun. 2020, ISSN: 2473-2400. DOI: 10.1109/TGCN.2019.2961192.

[100] A. E. Husain Bohra and V. Chaudhary, "VMeter: Power modelling for virtualized clouds," in *2010 IEEE International Symposium on Parallel Distributed Processing, Workshops and Phd Forum (IPDPSW)*, April 2010, pp. 1–8. DOI: 10.1109/IPDPSW.2010.5470907.

[101] L. M. Moreira Zorello, M. G. Torres Vieira, R. A. Girani Tejos, M. A. Torres Rojas, C. Meirosu, and T. C. Melo de Brito Carvalho, "Improving Energy Efficiency in NFV Clouds with Machine Learning," in *2018 IEEE 11th International Conference on Cloud Computing (CLOUD)*, Jul. 2018, pp. 710–717. DOI: 10.1109/CLOUD.2018.00097.

[102] J. Stoess, C. Lang, and F. Bellosa, "Energy Management for Hypervisor-Based Virtual Machines," in *USENIX Annual Technical Conference*, Santa Clara, CA, Jun. 2007.

[103] (2020). Virtio - KVM, [Online]. Available: https://www.linux-kvm.org/page/Virtio (visited on 08/27/2020).

[104] (December 20, 2014). Poll Mode Driver — Data Plane Development Kit 20.11.0-rc0 documentation, [Online]. Available: https://doc.dpdk.org/guides/prog_guide/poll_mode_drv.html.

[105] (March 13, 2020). The Zeek Network Security Monitor, Zeek, [Online]. Available: https://zeek.org/ (visited on 10/02/2020).

[106] (May 24, 2015). Snort - Network Intrusion Detection & Prevention System, [Online]. Available: https://www.snort.org/ (visited on 10/02/2020).

[107] (2020). Open vSwitch, [Online]. Available: https://www.openvswitch.org/ (visited on 08/27/2020).

[108] L. Rizzo and G. Lettieri, "VALE, a switched ethernet for virtual machines," in *Proceedings of the 8th International Conference on Emerging Networking Experiments and Technologies*, ser. CoNEXT '12, New York, NY, USA: Association for Computing Machinery, December 10, 2012, pp. 61–72, ISBN: 978-1-4503-1775-7. DOI: 10.1145/2413176.2413185. [Online]. Available: https://doi.org/10.1145/2413176.2413185 (visited on 11/18/2020).

[109] R. Bruschi, F. Davoli, P. Lago, and J. F. Pajo, "Joint Power Scaling of Processing Resources and Consolidation of Virtual Network Functions," in *5th IEEE International Conference on Cloud Networking (Cloudnet)*, October 2016, pp. 70–75. DOI: 10.1109/CloudNet.2016.20.

[110] W. Wu, W. Lin, L. He, G. Wu, and C. Hsu, "A Power Consumption Model for Cloud Servers Based on Elman Neural Network," *IEEE Transactions on Cloud Computing*, pp. 1–1, 2019. DOI: 10.1109/TCC.2019.2922379.

[111] R. Łukasik. (December 6, 2019). Run-to-completion model in Data Plane processing - Nokia Wrocław, [Online]. Available: https://nokiawroclaw.pl/blog/post/run-to-completion-model-in-data-plane-processing/ (visited on 09/30/2020).

[112] C. Kai, V. Blesson, K. Peter, and N. D. S, "Power Modelling for Heterogeneous Cloud-Edge Data Centers," *Advances in Parallel Computing*, vol. 32, pp. 804–813, 2018, ISSN: 0927-5452. DOI: 10.3233/978-1-61499-843-3-804. [Online]. Available: https://www.medra.org/servlet/aliasResolver?alias=iospressISBN&isbn=978-1-61499-842-6&spage=804&doi=10.3233/978-1-61499-843-3-804 (visited on 12/17/2019).

[113] K. N. Khan, M. Hirki, T. Niemi, J. K. Nurminen, and Z. Ou, "RAPL in Action: Experiences in Using RAPL for Power Measurements," *ACM Transactions on Modeling and Performance Evaluation of Computing Systems*, vol. 3, no. 2, 9:1–9:26, March 22, 2018, ISSN: 2376-3639. DOI: 10.1145/3177754. [Online]. Available: https://doi.org/10.1145/3177754 (visited on 07/27/2020).

[114] I. Molnar. (2009). Performance Counters for Linux, v8, [Online]. Available: https://lwn.net/Articles/336542/ (visited on 07/23/2020).

[115] R. Bolla, R. Bruschi, A. Carrega, and F. Davoli, "Green network technologies and the art of trading-off," in *2011 IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS)*, April 2011, pp. 301–306. DOI: 10.1109/INFCOMW.2011.5928827.

[116] (). TPC-W Homepage, [Online]. Available: http://www.tpc.org/tpcw/ (visited on 02/11/2021).

[117] (January 2021). Advanced Configuration and Power Interface (ACPI) Specification — ACPI Specification 6.4 documentation. in collab. with uefi, [Online]. Available: https://uefi.org/specs/ACPI/6.4/ (visited on 03/02/2021).

[118] C. K. Keong, K. T. Wei, A. A. A. Ghani, and K. Y. Sharif, "Toward using software metrics as indicator to measure power consumption of mobile application: A case study," presented at the 9th Malaysian Software Engineering Conference (MySEC), December 2015, pp. 172–177. DOI: 10.1109/MySEC.2015.7475216.

[119] K. Li, "Optimal configuration of a multicore server processor for managing the power and performance tradeoff," *The Journal of Supercomputing*, vol. 61, no. 1, pp. 189–214, Jul. 1, 2012, ISSN: 0920-8542, 1573-0484. DOI: 10.1007/s11227-011-0686-1.

[120] C. Mobius, W. Dargie, and A. Schill, "Power Consumption Estimation Models for Processors, Virtual Machines, and Servers," *IEEE Transactions on Parallel and Distributed Systems*, vol. 25, no. 6, pp. 1600–1614, Jun. 2014, ISSN: 1045-9219. DOI: 10.1109/TPDS.2013.183.

[121] "Environmental management — Life cycle assessment — Principles and framework," Standards ISO 14040:2006, 2006. [Online]. Available: https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/03/74/37456.html (visited on 07/27/2020).

[122] (Jul. 29, 2017). L.1310 : Energy efficiency metrics and measurement methods for telecommunication equipment. in collab. with I. T. U. (ITU), [Online]. Available: https://www.itu.int/rec/T-REC-L.1310/en (visited on 07/27/2020).

[123] D. Schien, P. Shabajee, M. Yearworth, and C. Preist, "Modeling and Assessing Variability in Energy Consumption During the Use Stage of Online Multimedia Services," *Journal of Industrial Ecology*, vol. 17, no. 6, pp. 800–813, 2013, ISSN: 1530-9290. DOI: 10.1111/jiec.12065. [Online]. Available: https://onlinelibrary.wiley.com/doi/abs/10.1111/jiec.12065 (visited on 07/27/2020).

[124] "Measurement method for energy efficiency of network functions virtualization," November 2018. [Online]. Available: https://www.itu.int/rec/T-REC-L.1361/en (visited on 07/23/2020).

[125] J. L. Hennessy and D. A. Patterson, *Computer Architecture: A Quantitative Approach*. Morgan Kaufmann, November 23, 2017, 939 pp., ISBN: 978-0-12-811906-8. Google Books: cM8mDwAAQBAJ.

[126] T. Inoue, A. Aikebaier, T. Enokido, and M. Takizawa, "Algorithms for Selecting Energy-Efficient Storage Servers in Storage and Computation Oriented Applications," in *2012 IEEE 26th International Conference on Advanced Information Networking and Applications*, March 2012, pp. 920–927. DOI: 10.1109/AINA.2012.136.

[127] W. Al-Zubaedi and H. S. Al-Raweshidy, "A parameterized and optimized BBU pool virtualization power model for C-RAN architecture," in *IEEE EUROCON 2017 -17th International Conference on Smart Technologies*, Jul. 2017, pp. 38–43. DOI: 10.1109/EUROCON.2017.8011074.

[128] R. Mijumbi, J. Serrat, J.-L. Gorricho, and J. Rubio-Loyola. (December 1, 2015). On the Energy Efficiency Prospects of Network Function Virtualization. arXiv: 1512.00215 [cs], [Online]. Available: http://arxiv.org/abs/1512.00215 (visited on 07/15/2020).

[129] T. Dlamini, "Softwarization in Future Mobile Networks and Energy Efficient Networks," *Mobile Computing*, November 8, 2019. DOI: 10.5772/intechopen.89607. [Online]. Available: https://www.intechopen.com/books/mobile-computing/softwarization-in-future-mobile-networks-and-energy-efficient-networks (visited on 07/15/2020).

[130] C. Dumitrescu, *Design Patterns for Packet Procesing Applications on Multi-core Intel Architecture*, December 2008. [Online]. Available: https://www.intel.com/content/dam/www/public/us/en/documents/white-papers/ia-multicore-packet-processing-paper.pdf (visited on 09/29/2020).

[131] M. Hähnel, B. Döbel, M. Völp, and H. Härtig, "Measuring energy consumption for short code paths using RAPL," *ACM SIGMETRICS Performance Evaluation Review*, vol. 40, no. 3, pp. 13–17, January 4, 2012, ISSN: 0163-5999. DOI: 10.1145/2425248.2425252. [Online]. Available: https://doi.org/10.1145/2425248.2425252 (visited on 07/27/2020).

[132] TelecomTV. (Jul. 21, 2020). The 5G Core is Vital to Deliver the Promise of 5G, TelecomTV, [Online]. Available: https://www.telecomtv.com/content/intel-vsummit-5g-ran-5g-core/the-5g-core-is-vital-to-deliver-the-promise-of-5g-39164/ (visited on 02/17/2021).

[133] R. Bhyrraju, H. Chu, J. F. Karlsson-Taylor, D. Druta, M. Brenner, D. Gautam, I. Kitroser, T. Wocalewski, and S. Wright, *Gs_NFV-IFA011v020701p.Pdf*, 2.7.1, ser. Network Functions Virtualisation (NFV) Release 2 ETSI GS NFV-IFA 011. Sophia Antipolis Cedex - FRANCE: ETSI, Sep. 2019, 75 pp. [Online]. Available: https://www.etsi.org/deliver/etsi_gs/NFV-IFA/001_099/011/02.07.01_60/gs_NFV-IFA011v020701p.pdf (visited on 02/18/2021).

[134] (2021). The NANOG February 2021 Archive by thread. in collab. with E.-V. Depasquale, NANOG Mailing List Archive, [Online]. Available: https://mailman.nanog.org/pipermail/nanog/2021-February/thread.html (visited on 03/05/2021).

[135] W. Dargie, "A Stochastic Model for Estimating the Power Consumption of a Processor," *IEEE Transactions on Computers*, vol. 64, no. 5, pp. 1311–1322, May 2015, ISSN: 1557-9956. DOI: 10.1109/TC.2014.2315629.

[136] P. Garraghan, I. S. Moreno, P. Townend, and J. Xu, "An Analysis of Failure-Related Energy Waste in a Large-Scale Cloud Environment," *IEEE Transactions on Emerging Topics in Computing*, vol. 2, no. 2, pp. 166–180, Jun. 2014, ISSN: 2168-6750. DOI: 10.1109/TETC.2014.2304500.

[137] A. F. Monteiro and O. Loques, "Quantum Virtual Machine: A Scalable Model to Optimize Energy Savings and Resource Management," in *2015 27th International Symposium on Computer Architecture and High Performance Computing (SBAC-PAD)*, October 2015, pp. 194–201. DOI: 10.1109/SBAC-PAD.2015.24.

[138] N. K. Sharma, P. Sharma, and R. M. R. Guddeti, "Energy efficient quality of service aware virtual machine migration in cloud computing," in *2018 4th International Conference on Recent Advances in Information Technology (RAIT)*, March 2018, pp. 1–6. DOI: 10.1109/RAIT.2018.8389047.

[139] M. Zakarya and L. Gillam, "An Energy Aware Cost Recovery Approach for Virtual Machine Migration," in *Economics of Grids, Clouds, Systems, and Services*, J. Á. Bañares, K. Tserpes, and J. Altmann, Eds., ser. Lecture Notes in Computer Science, Cham: Springer International Publishing, 2017, pp. 175–190, ISBN: 978-3-319-61920-0. DOI: 10.1007/978-3-319-61920-0_13.

[140] T. Zhao, J. Wu, S. Zhou, and Z. Niu, "Energy-delay tradeoffs of virtual base stations with a computational-resource-aware energy consumption model," in *2014 IEEE International Conference on Communication Systems*, November 2014, pp. 26–30. DOI: 10.1109/ICCS.2014.7024759.

[141] A. Marletta. (2012). CPU Usage Limiter for Linux, [Online]. Available: http://cpulimit.sourceforge.net/ (visited on 07/27/2020).

[142] J. Son, T. He, and R. Buyya, "CloudSimSDN-NFV: Modeling and simulation of network function virtualization and service function chaining in edge computing environments," *Software: Practice and Experience*, vol. 49, no. 12, pp. 1748–1764, December 2019, ISSN: 0038-0644, 1097-024X. DOI: 10.1002/spe.2755. [Online]. Available: https://onlinelibrary.wiley.com/doi/abs/10.1002/spe.2755 (visited on 07/07/2020).

[143] D. A. Slomon, P. Yosifovich, M. E. Russinovich, and A. Lonescu, *System Architecture, Processes, Threads, Memory Management, and More*, Seven, ser. Windows Internals ; Part 1. Pearson Education, 2017, 800 pp. [Online]. Available: https://www.oreilly.com/library/view/windows-internals-seventh/9780133986471/ (visited on 07/27/2020).

[144] (May 5, 2017). CPU Analysis, Micrsoft, [Online]. Available: https://docs.microsoft.com/en-us/windows-hardware/test/wpt/cpu-analysis (visited on 07/27/2020).

[145] M. Goraczko. (February 23, 2010). Joulemeter: Computational Energy Measurement and Optimization, Microsoft Research, [Online]. Available: https://www.microsoft.com/en-us/research/project/joulemeter-computational-energy-measurement-and-optimization/ (visited on 07/27/2020).

[146] W. Lin, W. Wu, H. Wang, J. Z. Wang, and C.-H. Hsu, "Experimental and quantitative analysis of server power model for cloud data centers," *Future Generation Computer Systems*, vol. 86, pp. 940–950, Sep. 1, 2018, ISSN: 0167-739X. DOI: 10.1016/j.future.2016.11.034. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0167739X16306872 (visited on 12/17/2019).

[147] (May 15, 2014). Intel® Core™ i5-3230M Processor (3M Cache, up to 3.20 GHz) rPGA Product Specifications, [Online]. Available: https://ark.intel.com/content/www/us/en/ark/products/72164/intel-core-i5-3230m-processor-3m-cache-up-to-3-20-ghz-rpga.html (visited on 07/27/2020).

[148] "Mobile 3rd Generation Intel®CoreTM Processor Family, Mobile Intel® Pentium® Processor Family and Mobile Intel® Celeron® Processor Family," Datasheet 326768-006, Jun. 2013. [Online]. Available: https://www.intel.com/content/dam/www/public/us/en/documents/datasheets/3rd-gen-core-family-mobile-vol-1-datasheet.pdf (visited on 07/27/2020).

[149] M. Doleželová, J. Skarvada, J. Heves, Y. Ruseva, J. Reed, R. Landmann, and D. Domingo. (December 8, 2010). Power Management Guide Red Hat Enterprise Linux 6, Red Hat Customer Portal, [Online]. Available: https://access.redhat.com/documentation/en-us/red_hat_enterprise_linux/6/html/power_management_guide/index (visited on 07/27/2020).

[150] M. Chios, D. Clarke, P. Willis, A. Reid, J. Feger, M. Bugenhagen, W. Khan, M. Fargano, D. C. Cui, D. H. Deng, J. Benitez, U. Michel, H. Damker, K. Ogak, T. Matsuzaki, M. Fukui, K. Shimano, D. Delisle, Q. Loudier, C. Kolias, I. Guardini, E. Demaria, R. Minerva, A. Manzalini, D. López, F. J. R. Salguero, F. Ruhl, and P. Sen, "Network Functions Virtualisation. An Introduction, Benefits, Enablers, Challenges & Call for Action," in *SDN and OpenFlow World Congress*, Darmstadt, Germany, October 22–24, 2012.

[151] D. Molka, D. Hackenberg, R. Schöne, and M. S. Müller, "Characterizing the energy consumption of data transfers and arithmetic operations on x86-64 processors," in *International Conference on Green Computing*, August 2010, pp. 123–133. DOI: 10.1109/GREENCOMP.2010.5598316.

[152] A. Rahman, P. Lynch, P. Aranda, C. Bernardos, J. Zuniga, and L. Contreras, "Network Virtualization Research Challenges," Request For Comments (RFC) - Informational RFC 8568, ISSN: 2070-1721, April 2019. [Online]. Available: https://tools.ietf.org/html/rfc8568#page-18 (visited on 07/10/2020).

[153] Dahyun. (October 10, 2017). SR-IOV for NFV solutions - practical considerations and thoughts, [Online]. Available: http://man-glove.blogspot.com/2017/10/sr-iov-for-nfv-solutions-practical.html (visited on 07/27/2020).

[154] N. Schmitt, J. von Kistowski, and S. Kounev, "Towards a Scalability and Energy Efficiency Benchmark for VNF," in *Performance Evaluation and Benchmarking for the Analytics Era*, R. Nambiar and M. Poess, Eds., ser. Lecture Notes in Computer Science, Cham: Springer International Publishing, 2018, pp. 41–54, ISBN: 978-3-319-72401-0. DOI: 10.1007/978-3-319-72401-0_4.

[155] G. Chen, X. Bai, X. Huang, M. Li, and L. Zhou, "Evaluating services on the cloud using ontology QoS model," in *Proceedings of 2011 IEEE 6th International Symposium on Service Oriented System (SOSE)*, December 2011, pp. 312–317. DOI: 10.1109/SOSE.2011.6139122.

[156] "Cloud computing performance report," 2010.

[157] "Benchmark evaluation of 114 public clouds," 2014.

[158] K. Hwang, X. Bai, Y. Shi, M. Li, W. Chen, and Y. Wu, "Cloud Performance Modeling and Benchmark Evaluation of Elastic Scaling Strategies," *IEEE Transactions on Parallel and Distributed Systems*, vol. 27, pp. 1–1, January 1, 2015. DOI: 10.1109/TPDS.2015.2398438.

[159] S. Yu, H. Yang, R. Wang, Z. Luan, and D. Qian, "Evaluating architecture impact on system energy efficiency," *PLoS ONE*, vol. 12, no. 11, November 21, 2017, ISSN: 1932-6203. DOI: 10.1371/journal.pone.0188428. pmid: 29161317. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5697812/ (visited on 07/27/2020).

[160] A. Noureddine, A. Bourdon, R. Rouvoy, and L. Seinturier, "A preliminary study of the impact of software engineering on GreenIT," in *2012 First International Workshop on Green and Sustainable Software (GREENS)*, Zurich, Switzerland: IEEE, Jun. 2012, pp. 21–27. DOI: 10.1109/GREENS.2012.6224251. [Online]. Available: http://ieeexplore.ieee.org/document/6224251/ (visited on 10/23/2019).

[161] C. Jiang, Y. Wang, D. Ou, Y. Li, J. Zhang, J. Wan, B. Luo, and W. Shi, "Energy efficiency comparison of hypervisors," *Sustainable Computing: Informatics and Systems*, vol. 22, pp. 311–321, Jun. 1, 2019, ISSN: 2210-5379. DOI: 10.1016/j.suscom.2017.09.005. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S2210537917300963 (visited on 07/27/2020).

[162] A. Lewis, S. Ghosh, and N.-F. Tzeng, "Run-time energy consumption estimation based on workload in server systems," in *Proceedings of the 2008 Conference on Power Aware Computing and Systems*, ser. HotPower'08, San Diego, California: USENIX Association, December 7, 2008, p. 4.

[163] V. Eramo, M. Ammar, and F. G. Lavacca, "Migration Energy Aware Reconfigurations of Virtual Network Function Instances in NFV Architectures," *IEEE Access*, vol. 5, pp. 4927–4938, 2017, ISSN: 2169-3536. DOI: 10.1109/ACCESS.2017.2685437.

[164] C. Gu, H. Huang, and X. Jia, "Power Metering for Virtual Machine in Cloud Computing-Challenges and Opportunities," *IEEE Access*, vol. 2, pp. 1106–1116, 2014, ISSN: 2169-3536. DOI: 10.1109/ACCESS.2014.2358992.

[165] (Jul. 20, 2020). OProfile - A System Profiler for Linux (News), [Online]. Available: https://oprofile.sourceforge.io/news/ (visited on 07/27/2020).

[166] G. Sebastien, *Sysstat/sysstat*, Jul. 27, 2020. [Online]. Available: https://github.com/sysstat/sysstat (visited on 07/27/2020).

[167] B. Gregg. (Jun. 12, 2018). Linux perf Examples, [Online]. Available: http://www.brendangregg.com/perf.html (visited on 08/13/2019).

[168] A. Z. Netto and R. S. Arnold. (Jun. 12, 2012). Evaluate performance for Linux on POWER, [Online]. Available: http://www.ibm.com/developerworks/library/l-evaluatelinuxonpower/index.html (visited on 07/27/2020).

[169] M. Colmant, M. Kurpicz, P. Felber, L. Huertas, R. Rouvoy, and A. Sobe, "Process-level power estimation in VM-based systems," in *Proceedings of the Tenth European Conference on Computer Systems - EuroSys '15*, Bordeaux, France: ACM Press, 2015, pp. 1–14, ISBN: 978-1-4503-3238-5. DOI: 10.1145/2741948.2741971. [Online]. Available: http://dl.acm.org/citation.cfm?doid=2741948.2741971 (visited on 10/24/2020).

[170] A. K. Singh, C. Leech, B. K. Reddy, B. M. Al-Hashimi, and G. V. Merrett, "Learning-Based Run-Time Power and Energy Management of Multi/Many-Core Systems: Current and Future Trends," *Journal of Low Power Electronics*, vol. 13, no. 3, pp. 310–325, Sep. 1, 2017, ISSN: 1546-1998. DOI: 10.1166/jolpe.2017.1492. [Online]. Available: http://www.ingentaconnect.com/content/10.1166/jolpe.2017.1492 (visited on 10/08/2019).

[171] L. Ismail and E. H. Abed, "Linear Power Modeling for Cloud Data Centers: Taxonomy, Locally Corrected Linear Regression, Simulation Framework and Evaluation," *IEEE Access*, vol. 7, pp. 175 003–175 019, 2019, ISSN: 2169-3536. DOI: 10.1109/ACCESS.2019.2956881.

[172] C.-W. Tsai, C.-F. Lai, H.-C. Chao, and A. Vasilakos, "Big data analytics: A survey," *Journal of Big Data*, vol. 2, December 1, 2015. DOI: 10.1186/s40537-015-0030-3.

[173] M. Stockman, M. Awad, R. Khanna, C. Le, H. David, E. Gorbatov, and U. Hanebutte, "A novel approach to memory power estimation using machine learning," January 18, 2011, pp. 1–3. DOI: 10.1109/ICEAC.2010.5702284.

[174] S. S. Mangiafico, "P-values and R-square Values for Models," in *Summary and Analysis of Extension Program Evaluation in R*. New Brunswick, NJ: Rutgers Cooperative Extension, January 2016, p. 775. [Online]. Available: https://rcompanion.org/handbook/G_10.html.

[175] C. O. S. Sorzano, J. Vargas, and A. P. Montano. (March 12, 2014). A survey of dimensionality reduction techniques. arXiv: 1403.2877 [cs, q-bio, stat], [Online]. Available: http://arxiv.org/abs/1403.2877 (visited on 07/27/2020).

[176] "G.W.A.T.T. (Global 'What if' Analyzer of NeTwork Energy ConsumpTion)," Bell Labs application able to measure the impact of technologies like SDN & NFV on network energy consumption. 2015, p. 15. [Online]. Available: https://media-bell-labs-com.s3.amazonaws.com/pages/20150114_1907/GWATT_WhitePaper.pdf.

[177] F. D. Rossi, M. G. Xavier, C. A. F. De Rose, R. N. Calheiros, and R. Buyya, "E-eco: Performance-aware energy-efficient cloud data center orchestration," *Journal of Network and Computer Applications*, vol. 78, pp. 83–96, January 15, 2017, ISSN: 1084-8045. DOI: 10.1016/j.jnca.2016.10.024. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S1084804516302569 (visited on 07/27/2020).

[178] J. Shuja, K. Bilal, S. A. Madani, M. Othman, R. Ranjan, P. Balaji, and S. U. Khan, "Survey of Techniques and Architectures for Designing Energy-Efficient Data Centers," *IEEE Systems Journal*, vol. 10, no. 2, pp. 507–519, Jun. 2016, ISSN: 1937-9234. DOI: 10.1109/JSYST.2014.2315823.

[179] T. Mastelic, A. Oleksiak, H. Claussen, I. Brandic, J.-M. Pierson, and A. V. Vasilakos, "Cloud Computing: Survey on Energy Efficiency," *ACM Computing Surveys*, vol. 47, no. 2, 33:1–33:36, December 19, 2014, ISSN: 0360-0300. DOI: 10.1145/2656204. [Online]. Available: https://doi.org/10.1145/2656204 (visited on 03/02/2021).

[180] M. Ismail, W. Zhuang, E. Serpedin, and K. Qaraqe, "A Survey on Green Mobile Networking: From The Perspectives of Network Operators and Mobile Users," *IEEE Communications Surveys Tutorials*, vol. 17, no. 3, pp. 1535–1556, thirdquarter 2015, ISSN: 1553-877X. DOI: 10.1109/COMST.2014.2367592.

[181] A. P. Bianzino, C. Chaudet, D. Rossi, and J. Rougier, "A Survey of Green Networking Research," *IEEE Communications Surveys Tutorials*, vol. 14, no. 1, pp. 3–20, First 2012, ISSN: 1553-877X. DOI: 10.1109/SURV.2011.113010.00106.

[182] G. Faraci and G. Schembra, "An Analytical Model to Design and Manage a Green SDN/NFV CPE Node," *IEEE Transactions on Network and Service Management*, vol. 12, no. 3, pp. 435–450, Sep. 2015, ISSN: 1932-4537. DOI: 10.1109/TNSM.2015.2454293.

[183] M. F. Tuysuz, Z. K. Ankarali, and D. Gözüpek, "A survey on energy efficiency in software defined networks," *Computer Networks*, vol. 113, pp. 188–204, February 11, 2017, ISSN: 1389-1286. DOI: 10.1016/j.comnet.2016.12.012. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1389128616304273 (visited on 03/02/2021).

[184] D. Qi, S. Shen, and G. Wang, "Virtualized Network Function Consolidation Based on Multiple Status Characteristics," *IEEE Access*, vol. 7, pp. 59 665–59 679, 2019, ISSN: 2169-3536. DOI: 10.1109/ACCESS.2019.2915919.

[185] S. Kim, S. Park, Y. Kim, S. Kim, and K. Lee, "VNF-EQ: Dynamic placement of virtual network functions for energy efficiency and QoS guarantee in NFV," *Cluster Computing*, vol. 20, no. 3, pp. 2107–2117, Sep. 1, 2017, ISSN: 1573-7543. DOI: 10.1007/s10586-017-1004-3. [Online]. Available: https://doi.org/10.1007/s10586-017-1004-3 (visited on 03/02/2021).

[186] R. Bolla, R. Bruschi, F. Davoli, and C. Lombardo, "Fine-Grained Energy-Efficient Consolidation in SDN Networks and Devices," *IEEE Transactions on Network and Service Management*, vol. 12, no. 2, pp. 132–145, Jun. 2015, ISSN: 1932-4537. DOI: 10.1109/TNSM.2015.2431074.

[187] I. F. Akyildiz, A. Kak, and S. Nie, "6G and Beyond: The Future of Wireless Communications Systems," *IEEE Access*, vol. 8, pp. 133 995–134 030, 2020, ISSN: 2169-3536. DOI: 10.1109/ACCESS.2020.3010896.

[188] "Smart Networks in the Context of NGI," Expert Advisory Group of the European Technology Platform Networld 2020, Sep. 2020. [Online]. Available: https://bscw.5g-ppp.eu/pub/bscw.cgi/d367342/Networld2020%20SRIA%202020%20Final%20Version%202.2%20.pdf (visited on 03/18/2021).

[189] Chongya Ma, Zhiying Jiang, Ke Zhang, Guangfei Zhang, Zhixiong Jiang, Chunyang Lu, and Yushan Cai, "Virtual machine power metering and its applications," in *2013 IEEE Global High Tech Congress on Electronics*, Shenzhen: IEEE, November 2013, pp. 153–156, ISBN: 978-1-4799-3209-2. DOI: 10.1109/GHTCE.2013.6767262. [Online]. Available: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=6767262 (visited on 09/09/2018).

[190] X. Wu, Y. Zeng, and G. Lin, "An Energy Efficient VM Migration Algorithm in Data Centers," in *2017 16th International Symposium on Distributed Computing and Applications to Business, Engineering and Science (DCABES)*, Anyang: IEEE, October 2017, pp. 27–30, ISBN: 978-1-5386-2162-2. DOI: 10.1109/DCABES.2017.14. [Online]. Available: http://ieeexplore.ieee.org/document/8253029/ (visited on 01/29/2021).

[191] A. Carrega, G. Portomauro, M. Repetto, and G. Robino, "Boosting Energy Efficiency and Quality of Service through Orchestration Tools," *IEEE Cloud Computing*, vol. 5, no. 6, pp. 38–47, November 2018, ISSN: 2325-6095, 2372-2568. DOI: 10.1109/MCC.2018.064181119.

[192] F. Rossi, M. Xavier, C. De Rose, R. Calheiros, and R. Buyya, "E-eco: Performance-Aware Energy-Efficient Cloud Data Center Orchestration," *Journal of Network and Computer Applications*, vol. 78, November 16, 2016. DOI: 10.1016/j.jnca.2016.10.024.

[193] C. Wen and Y. Mu, "Power and Performance Management in Nonlinear Virtualized Computing Systems via Predictive Control," *PLOS ONE*, vol. 10, no. 7, e0134017, Jul. 30, 2015, ISSN: 1932-6203. DOI: 10.1371/journal.pone.0134017.

[194] (October 7, 2019). Swarm mode overview, Docker Documentation, [Online]. Available: https://docs.docker.com/engine/swarm/ (visited on 10/08/2019).

[195] (). Production-Grade Container Orchestration, [Online]. Available: https://kubernetes.io/ (visited on 10/08/2019).

[196] (). Apache Mesos, Apache Mesos, [Online]. Available: http://mesos.apache.org/ (visited on 10/08/2019).

[197] D. C. Devi and V. R. Uthariaraj, "Load Balancing in Cloud Computing Environment Using Improved Weighted Round Robin Algorithm for Nonpreemptive Dependent Tasks," *The Scientific World Journal*, vol. 2016, pp. 1–14, 2016, ISSN: 2356-6140, 1537-744X. DOI: 10.1155/2016/3896065.

[198] M. Hinz, G. P. Koslovski, C. C. Miers, L. L. Pilla, and M. A. Pillon, "A Cost Model for IaaS Clouds Based on Virtual Machine Energy Consumption," *Journal of Grid Computing*, vol. 16, no. 3, pp. 493–512, Sep. 2018, ISSN: 1570-7873, 1572-9184. DOI: 10.1007/s10723-018-9440-8. [Online]. Available: http://link.springer.com/10.1007/s10723-018-9440-8 (visited on 10/08/2019).

[199] R. Bolla, R. Bruschi, F. Davoli, L. Di Gregorio, P. Donadio, L. Fialho, M. Collier, A. Lombardo, D. Reforgiato Recupero, and T. Szemethy, "The Green Abstraction Layer: A Standard Power-Management Interface for Next-Generation Network Devices," *IEEE Internet Computing*, vol. 17, no. 2, pp. 82–86, March 2013, ISSN: 1089-7801. DOI: 10.1109/MIC.2013.39. [Online]. Available: http://ieeexplore.ieee.org/document/6488673/ (visited on 11/17/2019).

[200] *L.1362 : Interface for power management in network function virtualization environments - Green abstraction Layer version 2*, in collab. with I. T. U. (ITU), August 13, 2019. [Online]. Available: https://www.itu.int/rec/T-REC-L.1362-201908-I/en (visited on 02/21/2021).

[201] "Network Functions Virtualisation (NFV); Management and Orchestration," ETSI, Sophia Antipolis Cedex - FRANCE, DGS/NFV-MAN001, December 2014.

[202] D. Laganà, C. Mastroianni, M. Meo, and D. Renga, "Reducing the Operational Cost of Cloud Data Centers through Renewable Energy," *Algorithms*, vol. 11, no. 10, p. 145, Sep. 27, 2018, ISSN: 1999-4893. DOI: 10.3390/a11100145. [Online]. Available: http://www.mdpi.com/1999-4893/11/10/145 (visited on 10/08/2019).

[203] A. Forestiero, C. Mastroianni, M. Meo, G. Papuzzo, and M. Sheikhalishahi, "Hierarchical Approach for Efficient Workload Management in Geo-Distributed Data Centers," *IEEE Transactions on Green Communications and Networking*, vol. 1, no. 1, pp. 97–111, March 2017, ISSN: 2473-2400. DOI: 10.1109/TGCN.2016.2603586. [Online]. Available: http://ieeexplore.ieee.org/document/7557052/ (visited on 10/08/2019).