



## I/UCRC for Energy-Smart Electronic Systems – Publications List

### ES2 Publications and Presentations: 2012 – 2016

#### Project: *Thermodynamic Tools for Holistic Analysis and Optimization of Energy Efficient Data Centers*

- [1] Wemhoff, A. P.; del Valle, M.; Abbasi, K.; Ortega, A. (2013). Thermodynamic Modeling of Data Center Cooling Systems, paper InterPACK2013-73116, July 2013.
- [2] Abbasi, K.; del Valle, M.; Wemhoff, A. P.; Ortega, A. (2013). A Transient Model for Parallel Flow and Counter Flow Heat Exchangers, paper InterPACK2013-73118, July 2013.
- [3] Dardani, I.; Wemhoff, A. P. (2012) Analysis of Air Cooling Effectiveness for 1U Servers, ASME IMECE Nov. 2012, Undergraduate Research Symposium Poster Presentation.
- [4] Silva-Llanca, L., Ortega, A., Fouladi, K., del Valle, M., Sundaralingam, V., (2014). *Investigation of Exergy Destruction in CFD Modeling for a Legacy Air-Cooled Data Center*. Proceedings of the 2014 Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems (ITHERM 2014), Lake Buena Vista, FL, May 27-30, 2014
- [5] Abbasi, K., del Valle, M., Wemhoff, A. P., Ortega, A., (2013). *A Transient Model for Parallel Flow and Counter Flow Heat Exchangers*. Proceedings of ASME 2013 InterPACK, July 16-18, 2013, Burlingame, CA, paper InterPACK2013-73118.
- [6] Wemhoff, A. P., del Valle, M., Abbasi, K., Ortega, A., (2013). *Thermodynamic Modeling of Data Center Cooling Systems*. Proceedings of ASME 2013 InterPACK, July 16-18, 2013, Burlingame, CA, paper InterPACK2013-73116.
- [7] Wemhoff, A. P., Ortega, A., (2014) *An Exergy-Based Analysis of the Effects of Rear Door Heat Exchange Systems on Data Center Energy Efficiency*. Proceedings of 2014 IITHERM, May 27-30, 2014, Lake Buena Vista, FL.
- [8] Abbasi, K., Wemhoff, A. P., Ortega, A., (2014). *Detailed and Reduced Order Modeling of Steady State Counterflow Mechanical Draft Cooling Towers for Analysis of Data Center Energy Efficiency*. Proceedings of 2014 IITHERM, May 27-30, 2014, Lake Buena Vista, FL.
- [9] Bhalerao, A.; Ortega, A.; Wemhoff, A. P., *Thermodynamic Analysis of Hybrid Liquid-Air-Based Data Center Cooling Strategies*. Proceedings of IMECE 2014, 38359.
- [10] Fouladi, K.; Wemhoff, A. P.; Silva-Llanca, L.; Ortega, A., *Optimization of Data Center Cooling Efficiency Using Reduced Order Flow Modeling within a Flow Network Modeling Approach*. Proceedings of IMECE 2014, 39558.
- [11] Bhalerao, A.; Ortega, A.; Wemhoff, A. P., *Thermodynamic Analysis of Hybrid Liquid-Air-Based Data Center Cooling Strategies*. Proceedings of IMECE 2014, 38359
- [12] Daney, E.; Wemhoff, A. P.; Jones, G. F., *Engaging students in the complex issues surrounding data center thermal management*. Proceedings of 2014 ASEE Annual Conference.



- [13] Bhalerao, A., Wemhoff, A.P., “*Thermodynamic Analysis of Full Liquid-Cooled Data Centers*” Proceedings of the ASME 2015 International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems and ASME 2015 12<sup>th</sup> International Conference on Nanochannels, Microchannels, and Minichannels – InterPACKICNMM2015
- [14] Schaadt, J.; Fouladi, K.; Wemhoff, A. P.; Pigeon, J. G., *Load Capacity and Thermal Efficiency Optimization of a Research Data Center Using Computational Modeling*. Proceedings of 2015 InterPACK Conference.
- [15] Bhalerao, A.; Fouladi, K.; Silva-Llanca, L.; Wemhoff, A. P., *Rapid Predictions of Exergy Destruction in Data Centers Due to Airflow Mixing*. Numerical Heat Transfer, Part A: Applications, in press.
- [16] Fouladi, K.; Wemhoff, A. P.; Silva-Llanca, L.; Abbasi, K.; Ortega, A., *Optimization of Data Center Cooling Efficiency Using Reduced Order Flow Modeling Within a Flow Network Modeling Approach*. Submitted to Energy and Buildings.

**Project: *Energy-Efficient Scheduling in Data Centers* – (Ghose, BU)**

- [17] Case, S., Ghose, K., (2013). “*Dynamic Classification of Repetitive Jobs in Linux for Energy-Aware Scheduling: A Feasibility Study*.” Proceedings of the ENERGY-2013 Conference, March 2013
- [18] Case, S., Afram, F., Atkas, E., Ghose, K., (2012) “*Energy-Aware Load Direction for Servers: A Feasibility Study*”. Proceeding of Proc. Parallel and Distributed Processing Conference (PDP) 2012, pp. 359-367.

**Project: *Compact Models for Rapid Thermal Modeling of Data Centers***

- [19] Arghode, V. K., Kumar, P., Joshi, Y., Weiss, T., Meyer, G., “*Rack Level Modeling of Air Flow Through Perforated Tile in a Data Center*”, ASME 2012 International Mechanical Engineering Congress and Exposition, 9-15 November 2012, Houston, Texas.
- [20] Arghode, V. K., Joshi, Y., “*Room Level Modeling of a Contained Cold Aisle*”, International Symposium on Transport Phenomena, 19-22 November 2012, Auckland, New Zealand.
- [21] Sundaralingam, V., Arghode, V., Joshi, Y., “*Controller to Regulate Maximum Server CPU Temperatures in a Rack By Varying CRAC Supply Air Temperatures*”, ASME 2012 International Mechanical Engineering Congress and Exposition, 9-15 November 2012, Houston, Texas.
- [22] Sundaralingam, V., Arghode, V., Joshi, Y., Phelps, W., “*Experimental Characterization of Cold Aisle Containment for Data Centers*”, IEEE 2013 Semiconductor Thermal Measurement and Management Symposium, 17-21 March 2013, San Jose, California. Mar-2013



- [23] Arghode, V. K., Kumar, P., Joshi, Y., Weiss, T., Meyer, G., (2013) “*Rack Level Modeling of Air Flow Through Perforated Tile in a Data Center*”. Proceeding of the Journal of Electronics Packaging, July 2013
- [24] Arghode, V. K., Sundaralingam, V., Joshi, Y., Phelps, W., (2013). “*Thermal Characteristics of Open and Contained Data Center Cold Aisle.*” Journal of Heat Transfer, May 16, 2013
- [25] Sundaralingam, V., Joshi, Y., Isaacs, S., Kumar, P., (2012). “*Characterization of Transient Air Temperatures in a Data Center Following Chiller Failure.*” Proceeding of I. J. Trans. Phenomena, Nov-2012
- [26] Arghode, V. K., Joshi, Y., (2012). “*Modeling Strategies for Investigation of Air Flow through Perforated Tile in a Data Center*”. Proceedings of the IEEE Transactions on Components, Packaging and Manufacturing Technology, Nov., 2012
- [27] Arghode, V. K., Sundaralingam, V., Joshi, Y., Phelps, W., (2013). “*Thermal Characteristics of Open and Contained Data Center Cold Aisle.*” ASME Journal of Heat Transfer, v 135, p 061901-1-11, 2013.
- [28] Arghode, V. K., Kumar, P., Joshi, Y., Weiss, T., Meyer, G., (2013). “*Rack Level Modeling of Air Flow Through Perforated Tile in a Data Center.*” ASME Journal of Electronic Packaging, v 135, p 030902-1-07, 2013.
- [29] Arghode, V. K., Joshi, Y., (2014). “*Room Level Modeling of Air Flow in a Contained Data Center Aisle.*” ASME Journal of Electronic Packaging, v 136, p 011011-1-10, 2014.
- [30] Arghode, V. K., Sundaralingam, V., Joshi, Y., (2013) “*Air Flow Management in a Contained Cold Aisle using Active Fan Tiles for Energy Efficient Data Center Operation.*” Proceeding of the International Workshop on Heat Transfer Advances for Energy Conservation and Pollution Control, 18-21 October 2013, Xi’an, Shaanxi, China.
- [31] Arghode, V. K., Joshi, Y., (2013), “*Experimental Investigation of Air Flow through Perforated Tile in a Raised Floor Data Center*”. Proceedings of International Symposium on Transport Phenomena, 01-05 November 2013, Yamaguchi, Japan.
- [32] Sundaralingam, V., Arghode, V. K., Joshi, Y., (2013). “*Experimental Comparison of Active Tiles with Passive Tiles in a Raised Floor Data Center.*” Proceedings of the International Symposium on Transport Phenomena, 01-05 November 2013, Yamaguchi, Japan.

**Project: Maximizing Use of Efficient Air-Side Economization in Modular, Large Data Centers and Datacom Housing Units**

- [33] Gebrehiwot, B., Dhiman, N., Rajagopalan, K., Agonafer, D., Kannan, N., Hoverson, J., Kaler, M. (2013) “*CFD Modeling of Indirect/Direct Evaporative Cooling Unit for Modular Data Center Applications.*” Proceedings of the ASME 2013 International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems. ASME.
- [34] Gebrehiwot, B., Aurangabadkar, K., Kannan, N., Agonafer, D., Sivanandan, D., Hendrix, M., (2012) “*CFD Analysis of Free Cooling of Modular Data Centers*”. Proceedings of the Semiconductor Thermal Measurement and Management Symposium (SEMI-THERM), 2012 28th Annual IEEE , vol., no., pp.108-111, 18-22 March 2012



[35] Gebrehiwot, B. , Dhiman, N., Rajagopalan, K., Agonafer, D., Kannan, N., Hoverson, J., & Kaler, M. (2013).” *CFD Modeling of Indirect/Direct Evaporative Cooling Unit for Modular Data Center Applications.*” Proceedings of ASME 2013 International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (pp. V002T08A054-V002T08A054). American Society of Mechanical Engineers (ASME).

[36] Gebrehiwot, B., Aurangabadkar, K., Kannan, N., Agonafer, D., Sivanandan, D., & Hendrix, M. (2012). “*CFD Analysis of Free Cooling of Modular Data Centers*”. Proceeding of the Semiconductor Thermal Measurement and Management Symposium (SEMI-THERM), 2012 28th Annual IEEE (pp. 108-111). IEEE.

**Project: *Direct and Indirect Evaporative Cooling for IT Pods (Phase II)***

[37] Sathyanarayan, S., Gebrehiwot, B., Sreeram, V., Sawant, D., Agonafer, D., Kannan, N., Hoverson, J., and Kaler, M., *Steady State CFD Modeling of an IT Pod and its Cooling System.* SEMI-THERM 2015.

[38] Sreeram, V., Gebrehiwot, B., Sathyanarayan, S., Sawant, D., Agonafer, D., Kannan, N., Hoverson, J., and Kaler, M., *Factors that Affect the Performance Characteristics of Wet Cooling Pads for Data Center Applications.* SEMI-THERM 2015.

**Project: *Dynamic Thermal Management and Controls in a Data Center (Sammakia, BU)***

[39] Alkharabsheh, S., Ibrahim, M. , Shrivastava, S., Sammakia, B., (2012). *Transient Analysis for Contained-Aisle-Data Centers.* Proceedings of IMECE2012, Houston, TX.

[40] Alkharabsheh, S. A., Sammakia, B. G., Shrivastava, S. K., Schmidt, R., *Utilizing Practical Fan Curves in CFD Modeling of a Data Center.* Proceeding of SEMI-THERM, San Jose, CA, USA.

[41] Alkharabsheh, S. A. , Sammakia, B. G. , Shrivastava, S. k., Ellsworth, M., David, M., Schmidt, R., (2013) *Numerical Steady State and Dynamic Study Using Calibrated Fan Curves for CRAC Units and Servers.* Proceedings at InterPACK, San Francisco, CA, USA.

**Project: *Computational and Experimental Models in Design of Dynamic, Energy-Efficient Cooling Solutions for Very High Power Data Centers***

[42] Fernandes, J., Ghalambor, S., Docca, A., Aldham, C., Agonafer, D., Chenelly, E., Chan, B., Ellsworth, M. Jr., (2013). *Combining Computational Fluid Dynamics (CFD) and Flow Network Modeling (FNM) for Design.* Proceedings of InterPACK 2013, San Francisco

[43] Ghalambor S., Fernandes J., Agonafer D. and Mulay V., (2013). *Improving the Thermal Performance of a Forced Convection Air Cooled Solution – Part 1: Modification of Heat Sink Assembly.* Proceeding of the 12<sup>th</sup> International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK), July 16-18 2013, Burlingame, CA.

[44] Fernandes J., Ghalambor S., Eiland R., Agonafer D. and Mulay V., (2013). *Improving the Thermal Performance of a Forced Convection Air Cooled Solution – Part 2: Effect on System-Level Performance.* Proceeding of the 12<sup>th</sup> International Technical Conference and Exhibition on Packaging



and Integration of Electronic and Photonic Microsystems (InterPACK), July 16 - 18 2013, Burlingame, CA.

[45] Fernandes J., Ghalambor S., Docca A., Aldham C., Agonafer D., Chenelly E., Chan B. and Ellsworth M.J., (2013). *Combining Computational Fluid Dynamics (CFD) and Flow Network Modeling (FNM) for Design of a Multi-Chip Module (MCM) Cold Plate*. Proceedings of the 12<sup>th</sup> International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK), July 16 - 18 2013, Burlingame, CA.

**Project: *Models and Metrics for Dynamic Air and Hybrid Liquid Cooled Data Centers Based on Computational and Experimental Approaches***

[46] Del Valle, M., A. Ortega, (2014). *Numerical and Compact Models to Predict the Transient Behavior of Cross-flow Heat Exchangers in Data Center Applications*. Proceedings of the 2014 Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems (ITHERM 2014), Lake Buena Vista, FL, May 27-30, 2014.

[47] Gao. T, Sammakia, B., Murray, B., Ortega, A., Schmidt, R., (2014). *Data Center Crossflow Heat Exchanger Study under Different Transient Temperature Boundary Conditions*. Proceedings of the 2014 IEEE Semiconductor Thermal Measurement and Management Symposium (SEMITHERM 30), San Jose, CA, March 9-13, 2014.

[48] Gao. T, Sammakia, B., Murray, B., Ortega, A., Schmidt, R., (2014). *Transient Effectiveness Characteristics of Cross Flow Heat Exchanger in Data Center Cooling Systems*. Proceedings of the 2014 Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems (ITHERM 2014), Lake Buena Vista, FL, May 27-30, 2014

[49] Alissa, H., Alkharabsheh, S., Bhopte, S., Sammakia, B., (2014). *Numerical Investigation of Underfloor Obstructions in Open-Contained Data Center with Fan Curves*. Proceedings of ITHERM2014, Lake Buena Vista, FL, May 27-30, 2014

[50] Gao. T, Sammakia, B., Murray, B., Ortega, A., Schmidt, R., (2014). *Cross Flow Heat Exchanger Modeling of Transient Temperature Input Conditions*. Proceeding of the IEEE Transactions on Components, Packaging, and Manufacturing Technology, 2014.

[51] Gao, T., Sammakia, B., Geer, J., Ortega, A., Schmidt, R., (2014). *Dynamic Analysis of Cross Flow Heat Exchangers in Data Centers using Transient Effectiveness Method,* IEEE Transactions on Components, Packaging, and Manufacturing Technology, 2014.

[52] Alkharabsheh, S., Sammakia, B., Shrivastava, S., Ellsworth, M., David, M., Schmidt, R., (2013). *A Numerical Steady and Dynamic Study in a Data Center Using Calibrated Fan Curves for CRACS and Servers*. Proceedings of the ASME 2013 International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems InterPACK2013 July 16-18, 2013, Burlingame, CA, USA IPACK2013-73217

[53] Gao, T., Sammakia, B., Schmidt, R., (2013). *Computational Study of Air Cooled Data Centers Assisted with Locally Distributed Water to Air Heat Exchangers*. Proceedings of IMECE, IMECE2013-65958, November 15-21, 2013 San Diego, California, USA



- [54] Song, Z., Murray, B., Sammakia, B., (2013). "Airflow and temperature distribution optimization in data centers using artificial neural networks" *International Journal of Heat and Mass Transfer* 64, (2013): 80-90
- [55] Song, Z., Murray, B., Sammakia, B., (2014). "A dynamic compact thermal model for data center analysis and control using the zonal method and artificial neural networks." *Applied Thermal Engineering* 62, no. 1 (2014): 48-57.
- [56] Song, Z., Murray, B., Sammakia, B., (2014). "Numerical investigation of inter-zonal boundary conditions for data center thermal analysis." *International Journal of Heat and Mass Transfer* 68, (2014): 649-658.
- [57] Song, Z., Murray, B., Sammakia, B., "A Compact Thermal Model for Data Center Analysis using the Zonal Method." *Numerical Heat Transfer, Part A: Applications* 64, no. 5, (2013): 361-377.
- [58] Song, Z., Murray, B., Sammakia, B., (2013). *Improved Zonal Model For Data Center Analysis*. Proceedings of the ASME 2013 International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems InterPACK2013 July 16-18, 2013, Burlingame, CA, USA IPACK2013-73048
- [59] Song, Z., Murray, B., Sammakia, B., (2013). *Prediction of Hot Aisle Partition Airflow Boundary Conditions*. Proceedings of the ASME 2013 International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems InterPACK2013 July 16-18, 2013, Burlingame, CA, USA IPACK2013-73049
- [60] Alkharabsheh, S., Sammakia, B., (2013). *Utilizing practical fan curves in CFD modeling of a data center*. Proceeding of Semiconductor, Thermal Measurement and Management Symposium (SEMI-THERM), 2013 29th Annual
- [61] Alkharabsheh, S., Shrivastava, S., Sammakia, B., (2013). *Effect of Containment System Perforation on Data Center Flow Rates and Temperatures*. Proceedings of ASME InterPACK2013, July 16-18, San Francisco, CA, USA
- [62] Alkharabsheh, S., Muralidharan, B., Ibrahim, M., Shrivastava, S., Sammakia, B. G., (2013). *Experimentally Validated CFD Model for Contained Cold Aisle Data Center*. Proceedings of ASME InterPACK2013, July 16-18, San Francisco, CA, USA
- [63] Alkharabsheh, S., Sammakia, B., Shrivastava, S., Schmidt, R., (2013). *A Numerical Study for Contained Cold Aisle Data Center Using CRAC and Server Calibrated Fan Curves*. Proceedings of ASME IMECE2013, November 15-21, San Diego, CA, USA
- [64] Gao, T., Samadiani, E., Sammakia, B., Schmidt, R., (2013). *Comparative Thermal And Energy Analysis Of A Hybrid Cooling Data Center With Rear Door Heat Exchangers*. Proceedings of the ASME 2013 International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems InterPACK2013 July 16-18, 2013, Burlingame, CA, USA IPACK2013-73101
- [65] Gao, T., Samadiani, E., Schmidt, R., Sammakia, B., (2013). *Dynamic analysis of hybrid cooling data centers subject to the failure of CRAC units*. Proceedings of the ASME 2013 International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems InterPACK2013 July 16-18, 2013, Burlingame, CA, USA IPACK2013-73196



- [66] Alkharabsheh, S. A., Sammakia, B. G., Shrivastava, S., and Schmidt, R., “*Dynamic Models of Servers Racks and CRAHs in a Room Level CFD Model of a Data Center,*” IEEE ITherm2014, May 27-30, Orlando, FL, USA
- [67] Alkharabsheh, S. A., Sammakia, B. G., Murray, B. T., Shrivastava, S., and Schmidt, R., “*Experimental Characterization of Pressure Drops in Servers Rack,*” IEEE ITherm2014, May 27-30, Orlando, FL, USA
- [68] Schaadt, J., M. Del Valle, and A. Ortega, “*Development of an Experimental Rig to Measure Transient Response of Crossflow Heat Exchanger,*” *Proceedings of The National Conference On Undergraduate Research (NCUR) 2014*, University of Kentucky, Lexington, KY, April 3-5, 2014.
- [69] Silva-Llanca, L., A. Ortega, K. Fouladi, M. del Valle, V. Sundaralingam, “*Investigation of Exergy Destruction in CFD Modeling for a Legacy Air-Cooled Data Center,*” *Proceedings of the 2014 Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems (ITHERM 2014)*, Lake Buena Vista, FL, May 27-30, 2014.
- [70] Alkharabsheh, S. A., Sammakia, B. G., Shrivastava, S., and Schmidt, R., “*Effect of Rack and Server Heat Capacity in a Physics Based Dynamic CFD Model of a Data Center,*” IEEE SEMI-THERM2014, March 9-13, San Jose, CA, USA
- [71] Alkharabsheh, S. A and Sammakia, B. G. , “*Physics Based Dynamic CFD Model of Data Centers,*” Presentation, Berkeley Symposium on Energy Efficient Electronic Systems, University of California, Berkeley, October 2013.
- [72] Alkharabsheh, S. A., Sammakia, B. G., Shrivastava, S., and Schmidt, R., “*A Numerical Study for Contained Cold Aisle Data Center Using CRAC and Server Calibrated Fan Curves ,*” ASME IMECE2013, November 15-21, San Diego, CA, USA
- [73] Zuk, B., A. Ortega, S. Schon, and D. Santoleri, “*Experiments and Modeling of a Two-Phase Thermosyphon based Thermal Management System for Rack Mounted Servers,*” *Proceedings of the 2014 IEEE Semiconductor Thermal Measurement and Management Symposium (SEMITHERM 30)*, San Jose, CA, March 9-13, 2014.
- [74] del Valle, M., and Ortega, A., 2015 *Experimental Characterization of the Transient Response of Air/Water Cross Flow Heat Exchanger for Data center Cooling Systems*, InterPACKICNMM2015, accepted to be presented at the ASME 2015 International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems and ASME 2015 13th International Conference on Nanochannels, Microchannels, and Minichannels
- [75] Silva-Llanca, L., del Valle, M., and Ortega, A., 2015, *The effectiveness of Data Center Overhead Cooling in Steady and Transient Scenarios: Comparison of Downward Flow to a Cold Aisle Versus Upwards Flow From a Hot Aisle*, InterPACKICNMM2015, accepted to be presented at the ASME 2015 International Technical Conference and Exhibition on Packaging and Integration of Electronic and Photonic Microsystems and ASME 2015 13th International Conference on Nanochannels, Microchannels, and Minichannels



- [76] Nemati, K., Alissa, H., Murray, B., Seymour, M., Sammakia, B., 2013, *Experimentally Validated Numerical Model of a Fully- Enclosed Hybrid Cooled Server Cabinet*, in InterPACK2015, San Francisco, CA, USA, 2015.
- [77] Alissa, H., A., Nemati, K., Sammakia, B., Ortega, A., King, D., Seymour, M., Tipton, R., " *Steady State And Transient Comparison Of Perimeter And Row-based Cooling Employing Controlled Cooling Curves*," InterPack 15, San Francisco, CA, USA, 2015.
- [78] Nemati, K., Gao, T., Murray, B., Sammakia, B., "*Experimental Characterization of the Rear Door Fans and Heat Exchanger of a Fully-Enclosed, Hybrid-Cooled Server Cabinet*" In Semiconductor Thermal Measurement and Management Symposium (SEMI-THERM), 2015 31th Annual, IEEE, San Jose, California, 2015.
- [79] Gao, T., Geer, J., Sammakia, B., "*Nonuniform Temperature Boundary Condition Effect on Data Center Cross Flow Heat Exchanger Dynamic Performance*," Int. J. Heat Mass Transfer 79, pp: 1048–1058, December, 2014.
- [80] Gao, T., Sammakia, B., Geer, J., Ortega, A., and Schmidt R., "*Dynamic Analysis of Cross Flow Heat Exchangers in Data Centers Using Transient Effectiveness Method*," IEEE Trans. Compon. Packag. Manuf. Technol., vol. 4, no. 12, pp. 1925 – 1935, November, 2014.
- [81] Gao T., Sammakia B., Samadiani, E., Schmidt R., 2013 "*Steady State and Transient Experimentally Validate Analysis of Hybrid Data Centers*," J. Electron. Packag. 137(2), pp: 021007-021007-12, Jun, 2015 Gao, T., David, M., Geer, J., Schmidt, R., and Sammakia, B., "A Dynamic Model of Failure Scenarios of the Dry Cooler in a Liquid Cooled Chiller-Less Data Center," In Semiconductor Thermal Measurement and Management Symposium (SEMI-THERM), 2015 31th Annual, IEEE, 2015.
- [82] Nemati, K., Gao, T., Murray, B., Sammakia B., "*Experimental Characterization of the Rear Door Fans and Heat Exchanger of a Fully-Enclosed Hybrid Cooled Server Cabinet*" In Semiconductor Thermal Measurement and Management Symposium (SEMI-THERM), 2015 31th Annual, IEEE, 2015.
- [83] Gao, T., Geer, J., Sammakia, B., "*Development and Verification of Compact Transient Heat Exchanger Models Using Transient Effectiveness Methodologies*" Int. J. Heat Mass Transfer 87, pp. 265–278, August, 2015.
- [84] Gao, T., Murray, B., Sammakia, B., "*Analysis of Transient and Hysteresis Behaviors of Cross-flow Heat Exchangers under Variable Fluid Mass Flow Rate for Data Center Cooling Applications*," Applied Thermal Engineering 84, pp:15-26, June 2015.
- [85] Gao, T., Sammakia, B., Geer, J., Murray, B., Tipton, R., Schmidt, R., "*Comparative Analysis of Different In Row Cooler Management Configurations in a Hybrid Cooling Data Center*," Proceedings of the ASME 2015 International Technical Conference on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK 2015), Paper No. InterPACK2015-48369, San Francisco, CA, July 6-9, 2015.





- [86] Gao, T., Geer, J., Tipton, R., Murray, B., Sammakia, B., Ortega, A., Schmidt, R., “*Raised Floor Hybrid Cooled Data Center: Effect on Rack Inlet Air Temperatures when In Row Cooling Units are installed between the Racks,*” Proceedings of the ASME 2015 International Technical Conference on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK 2015), Paper No. InterPACK2015-48371, San Francisco, CA, July 6-9, 2015.
- [87] Alissa, H.A., Nemati, K., B. Sammakia, A. Ortega, Seymour, M., King, D, “Comparative Study of Failure Scenarios between Hot and Cold Aisle Containment Using Perimeter and Row Based Cooling,” *Proceedings of the ASME 2015 International Technical Conference on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK 2015)*, Paper No. InterPACK2015-48237, San Francisco, CA, July 6-9, 2015.
- [88] Gao, T., Delvalle, M., Ortega, A., Sammakia, B., “*Numerical and Experimental Characterization of Transient Effectiveness of a Water to Air Heat Exchanger in data center cooling systems*” Proceedings of the ASME 2015 International Technical Conference on Packaging and Integration of Electronic and Photonic Microsystems (InterPACK 2015), Paper No. InterPACK2015-48371, San Francisco, CA, July 6-9, 2015.
- [89] Gao, T., Geer, J., Sammakia, B., Tipton, R., “Perimeter Cooling Unit and Localized Row-Based Cooling Unit Transient Air Flow Effects Modeling and Characterization in Data Centers” *IMECE 2015*
- [90] Alkharabsheh, S., Fernandes, J., Gebrehiwot, B., Agonafer, D., Ghose, K., Ortega, A., Joshi, Y., and Sammakia, B., *A Brief Overview of Recent Developments in Thermal Management and Energy Optimization in Data Centers*, ASME Journal of Electronic Packaging, 137 (4), 2015.
- [91] Silva-Llanca, L. and Ortega, A., “Direct Computation of Entropy Generation (Exergy Destruction) in an Air-Cooled Data Center using Computational Fluid Dynamic Simulation of a Legacy Air-Cooled Data Center,” 2016, (submitted)
- [92] Del Valle, M., C. Caceres, and A. Ortega, “Transient modeling and validation of chilled water based cross flow heat exchangers for local on-demand cooling in data centers,” *Proceedings of the 2016 Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems (ITHERM 2016)*, Las Vegas, NV, May 30-June 2, 2016.

**Project: Energy-Aware Virtualization for Data Centers (Ghose, BU)**

- [93] Case, S., Ghose, K., (2013). *Dynamic Classification of Repetitive Jobs In Linux For Energy-Aware Scheduling: A Feasibility Study*. Proceedings of ENERGY-2013 Conference, March 2013.
- [94] Case, S., Afram, F., Aktas, E., Ghose, K., (2012). *Energy-Aware Load Direction for Servers: A Feasibility Study*. Proceedings of Proc. Parallel and Distributed Processing Conference (PDP) 2012, pp. 359-367.

**Project: Impacts of Particulate and Gaseous Contamination on IT Equipment Where Air-Side Economizers are Implemented**

- [95] Singh, P., Klein, L., Agonafer, D., Pujara, K., Shah, J.M., (2015). *Effect of Relative Humidity, Temperature and Gaseous and Particulate Contaminations on IT Equipment Reliability*, InterPACK, 2015
- [96] Bagul, T., Pujara, K., Agonafer, D., Shah, J.M., Awe, O., (2015). *Computational Study Of Behavior Of Gas Absorption In Data Center Equipment And Its Effects On The Rate Of Corrosion/Contamination*, InterPACK, 2015
- [97] Pujara, K., Agonafer, D. (2015), *Effect of Gaseous Contamination on the corrosion of IT Equipment: An Experimental and Computational Analysis*, ASME/NSF Technical Paper Publication, 2015

**Project: Waste Heat Recovery and Reuse from Datacenters**

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