Mohan Krishnamoorthy

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Research Interests

Model-driven and algorithm engineering; big data analytics, decision support systems; decision optimization
The overarching goal of my research is threefold: (i) expand the horizon of modeling and analyzing complex real-world systems by designing solutions with high efficiency and usability, (ii) extend my understanding and gain expertise in areas/platforms such as serverless computing, cyber-physical systems, IoT, ubiquitous computing, simulation methods, machine learning, computational modeling, and operations research tools and paradigms, and (iii) leverage my experience in decision support, scientific algorithm engineering, and probabilistic modeling towards challenges involving accuracy, scalability, efficiency, and flexibility.

My Ph.D. thesis focuses on (i) designing highly reusable mathematical models of real-word manufacturing processes, (ii) building a prototype system for composition, analysis and optimization of reusable models, and (iii) designing efficient stochastic optimization algorithms based on deterministic approximations.

Looking forward, I am interested in working in an innovative organization in collaboration with creative, passionate and driven people, employ my strong problem solving skills, seek growth, and further my goals.

Education

2012–Present	**Ph.D. in Computer Science (expected June 2018)**,	*George Mason University*, *Fairfax, VA*.
	Advisors: Prof. Alexander Brodsky, Prof. Daniel Menascé	
2007–2010	**M.S. in Computer Science**,	*Rochester Institute of Technology*, *Rochester, NY*.
2003–2007	**B. Engg. in Computer Engineering**,	*Mumbai University*, *Mumbai, India*.

Experience

01/2013–Present Graduate Research Assistant, *George Mason University (GMU)*, Fairfax, VA.
Designed and developed reusable mathematical models for non-linear, stochastic, hierarchical, and temporal manufacturing processes from real-world data. Designed and developed one-stage stochastic optimization algorithms based on deterministic approximation heuristics.

01/2015–12/2017 Guest Researcher, *National Institute of Standards and Technology (NIST)*, Gaithersburgh, MD.
Designed and populated a repository of reusable mathematical models that were sourced from real-world data, publications, and crowdsourced data. Developed a software framework and prototype to perform composition, analysis, and optimization on reusable models.

08/2012–12/2012 Graduate Teaching Assistant, *George Mason University (GMU)*, Fairfax, VA.
Prepared and conducted labs, discussions, quizzes, and examinations of undergraduate courses in C/C++.

05/2010–06/2012 Research Technologist, *Los Alamos National Laboratory (LANL)*, Los Alamos, NM.
Designed and developed scientific algorithms for highly variable and large scale bioinformatics tools. Developed and debugged multiple backend modules of the HIV project. Redesigned the HIV website using Model-View-Controller (MVC) framework and web services.

07/2008–04/2010 Research Assistant, *Los Alamos National Laboratory (LANL)*, Los Alamos, NM.
Designed and developed Tree Viewer, Pruner and Decorator tools to perform selection and annotation of Influenza sequences. Designed and developed a schema for a large Influenza Sequence Database.

Projects

08/2014–Present Stochastic optimization algorithms based on deterministic approximations, *GMU*.
Purpose: Stochastic optimization algorithms that make use of the mathematical structure of the original problem are inefficient especially for real-world processes composed of complex process networks because they extract the mathematical structure using samples from a black-box simulation. The goal here is to improve the computation complexity and convergence of these algorithms for probabilistic models.
Contribution: Extracted the mathematical structure of the problem from a white-box simulation code analysis as part of a heuristic algorithm based on deterministic approximations to find the most optimal decision points for the system using statistics of the simulated probabilistic model.
Results: Experimental study on a 22-variable and 21-constraint real-world use case demonstrated that this approach significantly outperforms popular simulation-based optimization approaches. (**ICS'15, JDS'18**)

01/2016–12/2017   Framework for composition, analysis, and optimization of real-world processes, *NIST*.

Purpose: To build a system of reusable process models in manufacturing such that it is easy to use, simple, and cost-effective so that the end user can perform multiple analysis and optimization operations on these models.

Contribution: Built a software framework and prototype using Generic Model Environment and cloud architectures that allowed hierarchical composition, visualization, and analysis of manufacturing systems consisting of real-world processes from a reusable model repository.

Results: Demonstrated the prototype system to compose an hierarchical model for a real-world supply chain use case and performed simulation, prediction, optimization, and trade-off analysis using Pareto optimal graphs on this model. (**IEEE-BD'16, IEEE-BD'17**)

01/2015–12/2017   Reusable repository of process performance models, *GMU, NIST*.

Purpose: To build a reusable repository of models for manufacturing so that analysis and optimization solutions need not be implemented *de novo* because it leads to cost and time intensive development of models and algorithms, which are difficult to modify, extend, and reuse.

Contribution: Designed and developed a reusable repository of mathematical models called performance models for manufacturing end-users with the goal of ease of use and reusability to compose and perform analysis and optimization on complex real-world hierarchical processes.

Results: This repository was used as the basis for a competition to crowdsource Reusable Abstractions of Manufacturing Processes (RAMP) (tinyurl.com/y8fyakcl). For this competition, I also demonstrated the structure of a process performance model in an instructional webinar available at tinyurl.com/y87q4udv (**IEEE-BD'14, ICS-pr'15, JDS'15, IEEE-BD'15, IJAMT'16, HICSS'16**)

01/2011–07/2011   Scientific algorithm for Primer design, *LANL*.

Purpose: To build a tool for primer design, which is difficult to do for highly variable DNA sequences and for which experimental success requires attention to many interacting constraints.

Contribution: Designed and developed scalable scientific algorithm for primer design that included recursive generation of combinatorial bio-barcodes of specified length with design constraints and dimer risk filtration among the generated primer constructs in C and Perl.

Results: Primer design tool (v1.0) was included among the HIV analysis tools (current tool (v2.0) is at tinyurl.com/yd5hajbc). (**BMCbio'13**)

05/2010–12/2011   Redesign of computing architecture to improve efficiency of scientific analysis, *LANL*.

Purpose: To redesign scientific tools in order to ensure high performance and minimize compute time and file system usage.

Contribution: Designed and deployed five scientific tools using a Model-View-Controller (MVC) framework and web services using XML-RPC on the MVC model provided by Perl Catalyst and object oriented Moose libraries.

Results: The five tools were successfully deployed with an improvement of 35% in performance and 50% in file-system usage.

05/2009–06/2010   Masters Thesis: Compression and caching in distributed file system, *RIT*.

Purpose: To perform research on compression and caching algorithms to improve data fetch time in a distributed system.

Contribution & Results: Implemented a distributed system using the Java NIO framework and reduced data and file fetch time by 14%.

02/2009–04/2010   Tree Viewer, Pruner, and Decorator, *LANL*.

Purpose: To build tools that automate the selection and annotation of influenza genetic data by making the correct trade-off between speed and simplicity on the one hand and control over quality and contents of the data set on the other.

Contribution: Designed and developed the tree pruner and decorator tools to perform this selection and annotation for Influenza Sequence Database (ISD). This project was based on the open source project Archaeopteryx using Java Applets, AJAX, and REST web services with the JSON and phyloXML data formats.

Results: Pruner and Decorator tools were made available among influenza analysis tools and were also made open source. (**BMCbio'11**)

07/2008–04/2010   Database and Web architecture development, *LANL*.

Purpose: Design a schema to accommodate millions of records in ISD and develop a website over ISD to serve influenza analysis tools.

Contribution & Results: Designed a new schema in PostgreSQL. Also, developed a website over ISD using Perl, Mason Perl, HTML, XML, Java Scripts and SQL. Further, redesign of the website using jQuery and AJAX request objects yielded 23% better performance.

Skills, Expertise & Tools

Programming Languages & Libraries: Java (expert), C (proficient), C++ (proficient), LaTex (proficient), SQL (proficient), NoSQL (proficient), Ruby (familiar), Perl (proficient), Python (competent), Shell script (familiar), R (proficient), JavaScript (familiar), jQuery (familiar), XQuery (competent), JSONiq (proficient).

OS: Linux, Windows 7/8/10, MAC OS/X.

Functional abilities: Software Architecture, Object Oriented Programming, Distributed Business and Scientific Applications, Software Development and Testing, Data Mining and Analytics.

Mathematical modeling & Optimization Solvers: OPL, AMPL, CPLEX, Gurobi, MINOS, SNOPT, LGO, Coin OR, BARON, BONMIN.

Technical Skills: Data analytics, Analytical Modeling, Data Science, Algorithm Design, Decision Optimization, Operations Research, Decision Systems, Model Simulation & Prediction, Database Management Systems, Software Development Life Cycle.

Version control: GIT, Repo, SVN.

Tools: Docker, Eclipse, Emacs and VI editors, Oxygen XML editor, Rational Rose, Microsoft Visio, Microsoft Office, Microsoft Visual C++, Microsoft Visual Studio, gedit, Atom.

Internet Technology: Amazon AWS, Azure, Hadoop, OpenStack, Apache Spark.

Publications

[JDS'18] **M. Krishnamoorthy**, A. Brodsky, and D. Menascé. *Stochastic Decision Optimization based on Deterministic Approximations of Processes described as Closed-form Arithmetic Simulation.* In the Journal of Decision Systems (**JDS'18**), May 2018.

[IEEE-BD'17] A. Brodsky, **M. Krishnamoorthy**, M. O. Nachawati, and W.Z. Bernstein, D Menascé. *Manufacturing and Contract Service Networks: Composition, Optimization and Tradeoff Analysis based on a Reusable Repository of Performance Models.* In Proceedings of the 2017 IEEE International Conference on Big Data (**IEEE-BD'17**), Boston, MA.

[IEEE-BD'16] A. Brodsky, **M. Krishnamoorthy**, W. Z. Bernstein, M. O. Nachawati. *A System and Architecture for Reusable Abstractions of Manufacturing Processes.* In Proceedings of the 2016 IEEE International Conference on Big Data (**IEEE-BD'16**), Washington DC.

[IJAMT'16] A. Brodsky, G. Shao, **M. Krishnamoorthy**, A. Narayanan, D Menascé, and R. Ak. *Analysis and Optimization in Smart Manufacturing based on a Reusable Knowledge Base for Process Performance Models.* In the International Journal of Advanced Manufacturing Technology (**IJAMT'16**), April 2016.

[HICSS'16] **M. Krishnamoorthy**, A. Brodsky, and D. Menascé. *Modular Modeling & Optimization of Temporal Manufacturing Processes with Inventories.* In Proceedings of the 2016 Hawaii International Conference on System Sciences (**HICSS'16**), Kauai, HI.

[IEEE-BD'15] A. Brodsky, G. Shao, **M. Krishnamoorthy**, A. Narayanan, D Menascé, and R. Ak. *Analysis and Optimization in Smart Manufacturing based on a Reusable Knowledge Base for Process Performance Models.* In Proceedings of the 2015 IEEE International Conference on Big Data (**IEEE-BD'15**), Santa Clara, CA.

[JDS'15] D. Menascé, **M. Krishnamoorthy**, A. Brodsky. *Autonomic Smart Manufacturing.* In the Journal of Decision Systems, Special Issue on Integrated Decision Support Systems (**JDS'15**), June 2015.

[ICS'15] **M. Krishnamoorthy**, A. Brodsky, D. Menascé. *Optimizing Stochastic Temporal Manufacturing Processes with Inventories: An Efficient Heuristic Algorithm Based on Deterministic Approximations.* In Proceedings of the 2015 INFORMS Computing Society Conf. (**ICS'15**), Richmond, VA.

[ICS-pr'15] **M. Krishnamoorthy**, A. Brodsky, and D. A. Menascé. *Temporal manufacturing query language (tMQL) for domain specific composition, what-if analysis, and optimization of manufacturing processes with inventories.* As presented at the 2015 INFORMS Computing Society, did not appear in proceedings (**ICS-pr'15**), Richmond, VA. Also published as a Technical Report GMU-CS-TR-2014-3, Department of Computer Science, George Mason University, 2014.

[IEEE-BD'14] A. Brodsky, **M. Krishamoorthy**, D. Menascé, G. Shao, S.Rachuri. *Toward Smart Manufacturing Using Decision Analytics.* In Proceedings of the 2014 IEEE International Conference on Big Data (**IEEE-BD'14**), Washington DC.

[BMCbio'13] J. Brodin, **M. Krishnamoorthy**, G. Athreya, W. Fischer, P. Hraber, C. Gleasner, L. Green, B. Korber, T. Leitner. *A multiple-alignment based primer design algorithm for genetically highly variable DNA targets.* In BMC bioinformatics Journal (**BMCbio'13**), August 2013.

[BMCbio'11] **M. Krishnamoorthy**, P. Patel, M. Dimitrijevic, J. Dietrich, M. Green, C. Macken. *Tree pruner: An efficient tool for selecting data from a biased genetic database.* In BMC bioinformatics Journal (**BMCbio'11**), January 2011.

Preprints

[Under review] **M. Krishnamoorthy**, A. Brodsky, and D. Menascé. *Stochastic Optimization for Steady State Production Processes based on Deterministic Approximations.* Under review.

[Under prep.] **M. Krishnamoorthy**, A. Brodsky, and D. Menascé. *Scheduling Stochastic Processes with Inventories over Multiple Intervals.* Under preparation.

Talks

2017 *Service Networks: Stochastic Optimization based on Deterministic Approximations and Repository of Performance Models.* Doctoral Candidate Student Presentations at the 29th International Conference on Tools for Artificial Intelligence 2017, Boston, MA.

2017 *Manufacturing and Contract Service Networks: Composition, Optimization and Tradeoff Analysis based on a Reusable Repository of Performance Models.* IEEE International Conference on Big Data 2017, Boston, MA.

2016 *A System and Architecture for Reusable Abstractions of Manufacturing Processes.* IEEE International Conference on Big Data 2016, Washington DC.

2016 *Efficient Decision Support System for Discrete Manufacturing Processes.* Computer Science PhD Symposium, George Mason University, Fairfax, VA.

2015 *Analysis and Optimization in Smart Manufacturing based on a Reusable Knowledge Base for Process Performance Models.* IEEE International Conference on Big Data 2015, Santa Clara, CA.

2015 *Temporal manufacturing query language (tMQL) for domain specific composition, what-if analysis, and optimization of manufacturing processes with inventories.* INFORMS Computing Society Conference 2015, Richmond, VA.

2015 *Optimizing Stochastic Temporal Manufacturing Processes with Inventories: An Efficient Heuristic Algorithm Based on Deterministic Approximations.* INFORMS Computing Society Conference 2015, Richmond, VA.

2010 *Tree prune & decorator: An efficient tool for selecting and annotating data from a biased genetic database.* Theoretical Biology and Biophysics Seminar, Los Alamos National Laboratory, Los Alamos, NM.

Awards & Accomplishments

2018 Outstanding PhD Student Award from Computer Science Dept. at George Mason University, Fairfax, VA.

2014–2017 Travel Grant to attend the IEEE International Conference on Big Data.

2017 Travel Grant to attend the International Conference on Tools for Artificial Intelligence, Boston, MA.

2015 Travel Grant to attend the INFORMS Computing Society Conference, Richmond, VA.

2015–2017 Research Grant from National Institute of Standards and Technology, Gaithersburgh, MD.

2013–Present Graduate Research assistantship from George Mason University, Fairfax, VA.

2012–2017 Invited to join multiple honor societies for being an outstanding student.

2012–2013 Dean Fellowship Award from George Mason University, Fairfax, VA.

2008–2010 Research Assistantship from Los Alamos National Laboratory, Los Alamos, NM.

2007 Certificate of excellence for creating a budget database back end in SQL Server and web user interface for monitoring quarterly budgets, Mumbai, India.

References

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