Research Statement

Mustafa Al Lail

1 Scholarship Perspective

After spending a number of years in the IT industry, I realized that my passion lies elsewhere. I am strongly drawn to teaching, learning, and solving scientific problems, which are better suited to academia than the industry. I quit my job as a senior network engineer and pursued graduate studies in the United States. Towards this end, research allows me to fulfill one aspect of my career mission, that is: *doing outstanding research*. Such research will enable the development of software systems that enhance the quality of life of society.

I pursued research under the supervision of two distinguished professors. A prominent scholar in Cybersecurity, Dr. Indrakshi Ray, supervised my master's project. I did my doctoral research working with Dr. Robert B. France, the leading researcher in Model-Driven Software Development.

I engage in research that matters and I aim to produce significant results. While research can be done individually, I believe that collaboration yields more fruitful results in advancing science. I plan to maintain and build collaborations with scientists both from academia and the industry. Moreover, I believe in involving graduate and undergraduate students in my research. One of my long-term scholarship goals is to use my research and teaching expertise to contribute to the field of education in Computer Science. I plan to write a new textbook on teaching Formal Methods using the Unified Modeling Language (UML) and the Object Constraint Language (OCL).

2 Current Research Interests

1. **Software Engineering with a focus in Model-Driven Software Development(MDSD):** Research in MDSD aims to reduce the significant effort associated with developing and analyzing complex software systems through the creation and manipulation of software models. My long-term research goal is to contribute to the global effort to establish MDSD as a commonplace practice in software industry. My current projects focus on developing techniques and tools to formally specify and analyze complex software systems, define domain-specific modeling languages, and to optimize the analysis of large models.

2. **Cybersecurity with a focus in Access Control Models:** Access control models are used to mitigate the risks of unauthorized access to data, resources, and systems. My current research focuses on developing new technologies that address emerging problems in Online Social Networks (OSNs), business processes, and the medical domain.

3. **Formal Specification, Verification, and Validation of Software Systems:** Formal Methods research aims to improve the reliability and robustness of design through employing mathematical techniques for specification, validation, and verification of hardware and software systems. My current research focuses on integrating different formal techniques, e.g., model checking and automated theorem proving, with software modeling technologies. I am also investigating the development of new specification languages, verification techniques, and tools.

3 Current Research Projects

1. **A Software System for Spatio-Temporal Authorization:** The increasing dependency on digital technology has made the concept of data security an important concern. Not only how information is accessed, but also where and when have become important considerations in cyber-security. Certain situations exist where it is necessary to restrict access based on time and location. An example is a policy for a medical institution where doctors can only access patient records at hospitals during their shifts. The Generalized Spatio-Temporal Role-Based Access Control model (GSTRBAC) determines users' access to resources based on such information. This project aims to build a software architecture and an implementation of the GSTRBAC model.

   Accomplishments so far: The research project has yielded to the following two publications:

   1. Miguelangel Trevino, **Mustafa Al Lail**, "Database Web Application for Administering Spatio-Temporal Access Control Policies". Accepted at the 2021 International Conference of Advanced Research in Applied Science, Engineering and Technology (ICARASET'21).
   2. **Mustafa Al Lail**, Marshal Moncivais, Miguelangel Trevino, "Towards a Software System for Spatio-Temporal Authorization," To appear in The Journal of Computing Sciences in Colleges, (36, 7 2021).

2. **A Tool Support for Uncovering Faults in Software Design Models:** In the context of MDSD, designers use the Unified Modeling Language (UML) to create models that drive the entire development process. Once UML models are created, MDSD techniques automatically generate code from the models. If the models have undetected faults, they are propagated to code where they require considerable time and effort to detect and correct. It is therefore mandatory to analyze UML models at earlier stages of the development life-cycle to ensure the success of the MDE techniques in producing reliable software. One approach to uncovering design errors is to formally specify and analyze the properties that a system has to satisfy. Although significant research appears in specifying and analyzing properties, there does not exist an effective and efficient UML-based framework that specifies and analyzes temporal properties.

   This research project investigates the development of a novel software tool that uncovers faults in the designs of software. The uncovering and correcting of faults ensure that software development methods are capable of producing robust and reliable software.

   Accomplishments so far: The research project has yielded to the acceptance of following grant:

1. Mustafa Al Lail, "A Tool Support for Uncovering Faults in Software Design Models", University Research Grant, Texas A&M International University, 9/21 - 8/22, $10,000.

3.Secure Communication for Spatio-Temporal Access Control Software:

4 Future Research Projects and Collaborations

The following is a description of some of the projects I will be working on in the future. I have other projects, but for brevity, I only provide descriptions for a few of them.

1. An Access Control Model for Online Social Networks (OSNs): OSNs are gaining in popularity and are used by a large number of users with varied educational and socio-economic backgrounds. OSNs contain a plethora of personal information which, if misused, may cause enormous damage to individuals. A well-designed and user friendly authentication and access control mechanism are the initial steps towards protecting personal information stored on OSNs. This research project aims to produce an access control model suitable for OSNs.

Project Deliverable: A conference paper that will be submitted to the ACM Symposium on Access Control Models and Technologies (SACMAT 2022).

Collaborators: A potential graduate student and Dr. Indrakshi Ray, professor at Colorado State University.

2. An Object-Oriented Computational Tree Logic Language : Testing system behavior in real world applications often requires analyzing properties over multiple system states to ensure that operations do not interfere with each other in ways that are not desired. Such temporal constraints are necessary to model reactive and real-time systems. Before they can be analyzed, such properties need to be specified in a concise and precise manner. The Object Constraint Language (OCL) is widely used to express precise constraints on models and object oriented programs. However, the notion of temporal constraints, controlling the system behavior over time, has not been adequately supported. In this project, I plan to propose a new temporal logic language that is expressive to specify a variety of temporal properties.

Project Deliverable: A conference paper that will be submitted to the ACM/IEEE International Conference on Model Driven Engineering Languages and Systems (MODELS 2023).

Collaborators: A potential graduate student and Dr. Martin Gogolla at University of Bremen, Germany

3. The Success and Failure Factors of MDE and Formal Methods in Industry : Two of my research areas are Formal Methods and Model Driven Development. Unfortunately, both of these paradigms have low industry adoption. While Formal Methods have been around for more than 50 years now, MDSD approaches are relatively new. The MDSD community could benefit from the experience of Formal Methods in dealing with the adoption problem. In this project, I will investigate the reasons for the low adoption of FMs and compare and contrast them to the reasons of the low adoptions for MDSD techniques. The objective is to see how the formal methods community has responded to the low adoption. I hope to discover the lessons learned from the experience of Formal

Methods community that can be used improve the adoption of MDSD techniques.

Project Deliverable: A conference paper that will be submitted to the ACM/IEEE International Conference on Model Driven Engineering Languages and Systems (MODELS 2023).

Collaborators: None

4. **Evaluating The Property Specification Patterns:** Specifying temporal properties in formal languages such as Linear Temporal Logic and Computation Tree Logic can be challenging due to the mathematical maturity they require and their cumbersome notations. Dr. Matthew Dwyer and his colleagues proposed eight property specification patterns that aid in specifying temporal properties in different formal languages. However, these patterns, though very useful, were proposed more than 15 years ago. Many kinds of systems have emerged that require properties that can not be specified by the patterns. In this project, I will investigate and evaluate the applicability of the patterns to the new type of systems and requirements, and suggest proper extension.

   Project Deliverable: A conference paper that will be submitted to the Computer Aided Verification Conference (CAV 2024).

   Collaborators: None

5. **Discovering Software Properties:** Many formal methods techniques require a specification of the target system's desirable properties. When these properties are known, they can be specified using appropriate formalisms that can then be verified using different tools. Specifying these properties requires a deep understanding of the structure and the behavior of a system. For early stages of a system development, many of the properties are unknown. In this project, I plan to develop an approach that will aid in discovering system properties, which will aid in better understanding the system requirements. **Project Deliverable:** A conference proceeding paper will be submitted to the Computer Aided Verification Conference (CAV 2025).

   Collaborators: None