

# The International Center of Excellence in Software Engineering

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## Abstract:

*The International Center of Excellence in Software Engineering (ICESE) is a multifaceted center that aims at establishing active programs in research, outreach, and education. The significance of this center relies on its goal of bringing together on a tightly coupled fashion, and on a weekly or bi weekly basis through virtual meeting environments, researches from the Arab world and international researchers to work on projects that advance the state of the art in software engineering. The center focuses on applying Artificial Intelligence techniques to software engineering. It initially targets the development and application of model-based software engineering technology and focusing on developing methodologies for software architecture risk assessment leveraging data mining and artificial intelligence techniques.*

**Keywords:** Research Collaboration, Risk Assessment, Automated Software Engineering, Artificial Intelligence Techniques.

## 1. Introduction

Over the last many years, the world witnessed a significant growth in its communication and information technology industry in general and the software development industry in particular. Different studies and indicators place countries in the Arab world among the countries with the highest potential growth in these sectors, and foresee that the software industry could become one of the main contributors in economies in the decades to come. Applied research in software

engineering is needed in order to support the growth projected for these industries.

This article introduces the International Center of Excellence in Software Engineering (ICESE). This center is a research center being established through a project funded by the Qatar National Research Fund (QNRF). The ICESE project brings together researchers from five collaborating institutions in three different countries as shown in the authors list.

Many Software Engineering Research centers have been established in various countries to conduct research that support the software industry on challenging issues of software engineering technology. Some of these centers are briefly described as follows:

- The Software Engineering Institute at Carnegie Mellon University [12] has been in the forefront of software engineering technology research and development. As an applied research and development center established by the US Department of Defense, the SEI strives to benefit its research partners and provides benefits to the software industry as a whole.
- The Fraunhofer Center for Experimental Software Engineering at the University of Maryland [13] is another example of

university based research centers that conducts research projects on experimental software engineering.

- The Software Engineering Research Center (SERC) [14] is the US National Science Foundation Industry/University Cooperative Research Center. Throughout its many years of existence, this center has supported research in various areas related to Software Engineering and sponsored by member companies. SERC holds two annual workshops to provide progress presentations to member companies on the status of current projects

ICESE is different from the above centers in several ways. These are summarized as follows:

1. It brings together researchers from the US with researchers from different countries in the Arab world.
2. Research groups collaborate in conducting research in a tightly coupled fashion through virtual meetings, virtual workshops and conferences.
3. Collaborative proposals and publications define part of the success criteria for the center project
4. Knowledge transfer and collaboration with industry in the region is a major goal of the center and benefits to industry define another part of the success criteria of the center.

The article is organized as follows. In section 2, we summarize the mission and goals of the center. In section 3, we describe briefly the current research projected conducted by the center researchers. In section 4, we present the virtual workshop series organized by the center, and finally we give our concluding remarks in section 5.

## 2. Mission, and Goals

The mission of the international center of excellence in software engineering is to bring

together researchers in different institutions in Qatar and in different countries in the Middle East to conduct cutting-edge innovative research through funded projects in order to advance the state of the art and practice in software engineering.

The mission of ICESE is specified in more details as follows:

1. To bring together researchers from the Arab world and international researchers to work together on a tightly coupled fashion through virtual meeting environments.
2. To perform collaborative research on challenging issues of software engineering technology using artificial intelligence techniques that is critical to support the development, operation and maintenance of modern software-centric systems.
3. To provide cutting-edge technological support to the software industry in Qatar and the Arab world.
4. To enhance the competitiveness of member organizations from academia and industry by conducting collaborative research programs, developing joint *Research and Development* (R&D) proposals to compete for funding, and delivering high-quality educational and training programs both on-campus and off-campus.
5. To foster an environment of excellence for faculty, students, and industry colleagues for exploration of state of the art software engineering technology and artificial intelligence techniques through hands-on projects using modern tools.
6. To disseminate research results to the research community by conducting virtual workshops and conferences.

The short term goals of the center are the goals we strive to reach during the first few years of the project. They are listed as follows:

1. Establish the culture of conducting collaborative research between the center researchers
2. Identify specific research problems that can leverage the expertise of the center researchers and define focused projects.
3. Form research teams to tackle specific research problems related to the scope of research in the center.
4. Publish collaboratively survey papers and research papers describing proof of concepts and preliminary results in international journals, conferences and workshops
5. Present Research results at the center workshops and international meetings.

The long term goals of the center are the goals that fulfill the mission of the center over an extended period during and beyond the initial 3 years term of the center project. These are listed as follows,

1. Help center researchers to achieve a strong record of research publications and funded research projects
2. Develop an international reputation for the center
3. Acquire sustained funding for research projects from different funding sources
4. Facilitate knowledge transfer to industry and students.

More information about the center researchers and the center mission and goals

can be found at the web site for the center <http://www.bis-cmt.com/icese/>.

In the next section, we summarize the research focus areas in the center and give some examples of current projects conducted by the center researchers.

### **3. Current Research Areas and Projects**

In this section, we describe some of the current research projects conducted by the center researchers. We focus on two main areas. The first is based on risk assessment techniques of quality attributes of software architectures. This is due to the fact that software architectures play a major role in driving the management activities during the development and maintenance of software systems. The second area is AI techniques in software engineering. The work in this area is focused on automating software engineering tasks using AI techniques.

The following paragraphs describe specific research projects conducted by the center researchers and some of the research results produced by these projects:

#### **3.2. Risk Assessment of Quality Attributes**

Risk assessment of quality attributes at the architecture level is an important area of research that has attracted much attention recently with the advent of technologies such as service-oriented engineering and cloud computing. Service level Agreements are essential elements of these technologies. These agreements specify the quality of service expectations between service providers and service consumers. Quality based risk analysis and assessment has become an essential task conducted by service providers.

Risk assessment is an essential part in the management of software development.

Performing it in the early phases of software development can enhance allocation of resources within the software lifecycle. Also, it provides useful means for identifying potentially troublesome software components that require careful development and allocation of more testing effort. We are concerned with reliability-based risk, which takes into account the probability that the software product will fail in the operational environment and the consequences of that failure

Our research in software architecture risk assessment is based on using software architecture artifacts to estimate components and scenarios risk factors related to the quality attributes of performance, reliability, maintainability, and security [1-5]. This work has been previously supported by several funds from NASA and NSF to West Virginia University. In the following paragraphs, we briefly outline some of the research concepts developed in this work.

Model-based risk assessment covers different non-functional aspects that can be of concern to software development or maintenance such as reliability-based, performance-based risk, maintainability-based risk, and security-based risk. For example, reliability-based risk takes into account the probability that the software product of failure and the consequences or severity of such failure [4][5]. Severity assessment is a procedure by which the severity of failures of software architectural elements and scenarios are estimated and ranked accordingly.

Performance-based risk is measured by the probability of violating a performance objective in a given scenario, and the severity resulting from such violation. The methodology uses annotated architecture models to estimate the performance failure probability and severity measures [2].

A successful maintenance project requires a well planned maintenance effort to control the maintenance process and to reduce the risks associated with performing the required

maintenance tasks [6]. Prioritization of the required maintenance tasks is a key factor for having a well planned maintenance process. Thus, maintainability-based risk takes into account the probability that the software product will need to endure a certain type of maintenance and the consequences of performing this maintenance on the system.[7].

Security-based risk assessment is considered a significant and indispensable process in all phases of software development lifecycles, and most importantly at the early phases. A methodology using the Unified Modeling Language (UML) artifacts and Attack graphs is introduced in [8].

The current collaborative project conducted by ICESE researchers is focusing on developing and investigating the validity of risk assessment methodologies for security-based risk and maintainability-based risk of software architectures.

We are focusing on three research problems as follows:

1. We are developing a security-based risk assessment methodology and we are investigating the validity of this methodology by applying it to an E-Commerce case study.
2. For maintainability-based risk assessment, we are investigating the validity of the initial change probability distribution and its effects on the change propagation quality metrics.
3. We are investigating the application of maintainability-based risk assessment methodology on the MobileMedia software product line case study [11].

### **3.2. Artificial Intelligence in Software Engineering**

The process of developing contacts and partners with the software industry is an important on-going process in the center project. We discuss with industrial partners the patterns of software development related to data mining and software quality. Data mining and software defect detection and correction were chosen as important research areas.

For Data mining, we are focusing on research related to the principal of industrial data mining and Software Engineering. In [9] we discussed the practices of industrial data mining. These practices are very different from academic data mining. These differences have significant implications for

- (a) how we manage industrial data mining projects;
- (b) the direction of academic studies in data mining; and
- (c) training programs for engineers who seek to use data miners in an industrial setting.

We are also focusing on research work related to the application of artificial intelligence techniques to software defects detection and correction. This research is relevant to the software industry in the Arab world since software defects detection and correction is one of the most important software engineering tasks. Two research papers are under preparation in these efforts.

In particular we decided to explore two approaches:

- (a) Design Defects Detection and Correction Using Genetic Programming and
- (b) Design Defects Correction using Multi-objective optimization to minimize refactoring effort and maximize software quality.

For the first approach, we propose an automated approach for the detection and

correction of various types of design defects in source code. Our approach allows to automatically find detection rules, thus relieving the designer from doing so manually. Rules are defined as combinations of metrics/thresholds that better conform to known instances of design defects (defect examples). The correction solutions, a combination of refactoring operations, should minimize, as much as possible, the number of defects detected using the detection rules. In our work, we used genetic programming for rule extraction. For the correction step, we used genetic algorithm. We evaluated our approach by finding and fixing potential defects in four open-source systems. A journal paper on this work is now in press at the journal of Automated Software Engineering.

For the second approach, we extended our work done in the first approach to take into consideration the refactoring effort to be minimized while improving design quality. The techniques we have used in our approach were validated using large open source projects and the implemented tool can be used in industry to improve software quality design. We are currently conducting further experiments regarding this work.

#### **4. Virtual Workshops**

One of the aims of ICESE center is to conduct virtual workshop series to present and discuss advances in software engineering. The center conducts virtual workshops in form of Web-based Seminars. In the virtual workshops conducted by ICESE, we use the web conferencing technologies available on the market that have incorporated the use of VoIP (voice over Internet protocol) audio technology, to allow for a completely web-based communication. The First ICESE Virtual Workshop, in “Series on Software Engineering and Artificial Intelligence Search-based Model-Driven Engineering”, was conducted on 17-18 May 2011.

This first virtual workshop, hosted in Qatar University, covered various topics related to the application of artificial intelligence techniques in software engineering. In this first workshop, we focused on exploring existing work about the application of artificial intelligence techniques in Model-Driven Engineering: model transformation, model evolution, model refactoring, transformation testing, etc. To this end, we invited four speakers working on this domain from different universities in France, Austria, Hungary and Canada. The second version of the virtual workshop will be conducted in the end of April 2012. It will cover different topics related to the search-based software maintenance and different speakers will be invited. In addition, we plan to present during this workshop our research center activities related to the use of heuristic search and machine learning techniques to improve software quality.

## 5. Conclusions

In this paper, we demonstrate the activities conducted at The International Center of Excellence in Software Engineering (ICESE). The center goal is to coordinate outreach and collaborative research that involve research faculty with expertise on software engineering and artificial intelligence from multiple universities and industry collaborators.

The main focus of the center is applying Artificial Intelligence techniques to software engineering. The center research team concentrates on model-based software engineering technology and developing methodologies for software architecture risk assessment leveraging data mining and artificial intelligence techniques

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