Department of Electrical and Computer Engineering
University of Massachusetts Dartmouth

ECE544 Fault-Tolerant Computing & Reliability Engineering

Project Description

Fall 2022
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1 General Description

This project is designed to allow everyone in the class to pursue technical areas that are relevant to the class and are of particular interest to the students. In addition, the project is an opportunity for the students to learn more about a particular topic than can be presented in the class lectures.

2 Project Content & Objectives

As part of the project, you are expected to: 1) develop and understand the fundamental background material for the topic, 2) review current literature relevant to the project, 3) examine an application that illustrates the technology or the need for the technology studied in your project; experiment some technology through analytical modeling, simulation or implementation, 4) write a concise report summarizing the results of the project.

It is seldom possible that class projects can result in new technology, but you should strive to gain an understanding of the existing technology. My hope is that this class will prepare you to perform research or design systems in the fault tolerance and reliability engineering areas. Consequently, one of the most important aspects of the project is the review of the current literature. You will be expected to conduct a survey of the papers related to your chosen topic. The project should be regarded as a small research effort. It is my intention that the projects supplement the class lectures and homework. The project should be started immediately, and it is expected to continue throughout the semester.

3 Required Work

The project will be a *team* effort. Project teams should be set up within the first week of the class. The work required in the project consists of those items listed in the following sub-sections:

3.1 Proposal

While the purpose of this project format is to allow everyone to pursue a topic of interest, it is necessary to ensure that all topics are important to the technical content of this class. In addition, I want to make sure that similar amounts of effort are required for the various projects. Consequently, each team must submit a written proposal (one-page) on the project topic by **October 5 (Wednesday).**

The one-page proposal should clearly describe what you want to do for the project. The proposal should include at a minimum a description of the problem, the work to be performed, and the expected results. Be sure to include your name and the tentative title of your project. Please refer to *Proposal Guidelines* for the suggested formats. Proposals will be reviewed and must be approved by the instructor.

3.2 Meeting

After the proposal is submitted, you should schedule a meeting (in-person or virtual through Zoom) with the instructor to discuss your proposal, and ongoing processes for the project. The meeting should have completed by **October 28 (Friday)**. The meeting will result in a finalized project plan and expectations for the project.

3.3 Research Report

A report of your project in the required IEEE format should be submitted. The report must be informative with no more than 5 pages. The report must be submitted in soft copy by **November 30 (Wednesday)**. Please refer to *Report Guidelines* for the suggested format and requirements.

3.4 Project Presentation

A 25-minute presentation is expected for each project, with time for questions and discussions. The time duration of presentation subjects to changes based upon the final enrollment in the class and the actual number of projects. I will let you know precisely how much time you will have for your presentation later in the semester.

Your presentation should be self-contained, precise, and clear. Please refer to *Presentation Guidelines* for the suggested format and contents. Everyone in the class is expected to attend all of the oral presentations. I will take attendance at the presentations, and will use this information when I compute your overall grade for the project. The presentation slides must be submitted in soft copy by **December 5 (Monday)**. The scheduled time for presentations will be on **December 5 (Monday)** and **December 7 (Wednesday).**

4 Time-line

Budget your time wisely for the project. Plan a time table for your project and take pains to observe the deadlines.

- Project proposal due October 5 (Wednesday)
- Meeting with the instructor due October 28 (Friday)
- Project final report due November 30 (Wednesday)
- Project presentation slides due December 5 (Monday)
- Project presentation, December 5 (Monday) and December 7 (Wednesday)

5 Grading

Grading of the project will be based on the quality of your proposal and report, substantive content, appropriate organization, your demonstrated knowledge of the technical topic, your ability to understand applications of that knowledge, clarity of your presentation, use of allotted presentation time, and attendance at project presentations. The peer evaluation will also be taken into account.

Multiple errors in spelling and grammar will detract the clarity of your proposal/abstract and will be graded accordingly. So do use a spell checker. Verbatim copy should be avoided. Your report will be checked by SafeAssign, a plagiarism prevention tool. Also, you should explicitly acknowledge any sources of ideas used that are not your own; this includes other people, books, papers, web pages, etc. **Academic dishonesty will be "rewarded" with a grade of ZERO**. For more details, refer to Student Handbook:

https://www.umassd.edu/studentaffairs/studenthandbook/academic-regulations-and-procedures/

6 Potential Project Topics

Listed below are some examples of project topics. You may select one of the listed topics. **The list is by no means complete, so please feel free to propose alternative ideas.** I am very open to new ideas for projects. A well-organized proposal must be submitted by **October 5, Wednesday** for review and approval.

- *Fault-Tolerant System Design*. Numerous fault-tolerant systems have been designed in the past and applied to a variety of problems. One potential project could involve a case study of a particular design in modern applications, for example a cloud computing system, an Internet of Things (IoT) system, a cyber-physical system (CPS), a storage area network, or a space shuttle. The design techniques, analysis procedures, problems, and results would be studied. Several particular designs could also be examined and compared.

- *Reliability Modeling of Complete Systems*. Complete systems include not only hardware but also software components. Most reliability models consider one aspect of the system but not the system as a whole. This project could investigate the reliability modeling of complete systems including hardware and software elements. The intent is to examine possible approaches and to illustrate the impact of both hardware and software components on the reliability of a system.

- *Reliability Modeling of Noncoherent Systems*. Considerable research has been expended in the study of coherent systems. A system is coherent, meaning that each component contributes to the system state and the system state worsens (at lease does not improve) with an increasing number of component failures. But very little attention has been focused on noncoherent systems in the literature, despite their being general and applicable to modeling a large class of practical systems. The difficulty in analysis arises from the non-monotonic property of the system structure function. An example project might investigate the various modeling and analysis approaches that have been proposed for noncoherent systems, evaluate their performance, and possibly propose new techniques.

- *Ordering Issues in Binary Decision Diagrams (BDD)*. BDD are efficient combinatorial models in fault tree reliability analysis. To use the BDD, the fault-tree structure needs to be converted into the BDD format. Converting the fault tree is relatively straightforward but requires that the basic events of the tree be ordered. This ordering is critical to the resulting size of the BDD, and ultimately affects the qualitative and quantitative performance and benefits of the BDD technique. In other words, the advantages to be gained by utilizing BDD technique relies on the efficiency of the ordering scheme. An example project might investigate the various ordering schemes which have been proposed, evaluate their effectiveness, and possibly propose new and more efficient ordering schemes.

- *Safety-Critical Systems*. Designing a system for safety is very different than designing a system for reliability. In most safety-critical systems the option is available to discontinue the operation of the system. In other applications where reliability is important, it is not allowable to discontinue operations at any time. An example of a safety-critical system is a railway control system where a safe state is one in which all trains are stopped and all signals are red. The system is considered safe if it either operates correctly or enters the safe shutdown state. An example project might look at the different issues associated with designing and modeling safety-critical systems.

- *Dependability Evaluation Using Fault Injection*. One of the most difficult problems associated with the fault tolerance technology is predicting the dependability of a system. One typical approach is to perform fault injection on a complete hardware/software prototype or on a simulation model of the system. The results of the experiments are then used to predict the important attributes of the system. There are many problems with fault injection technology, including, for example, fault selection and the estimation of reliability and other metrics from the fault injection measurements. An example project might survey this technology and identify the key problems as well as performing a simple experiment.

- *Monte-Carlo Simulations for Reliability Analysis*. Monte Carol simulations is a powerful tool for modeling reliability of a complex system. One potential project would perform a Monte Carlo simulation of a particular system, for example, a body sensor network subject to competing failures, a fault-tolerant storage system with dynamic standby sparing. The simulated system and effects of different factors on the system reliability performance could be investigated.