SCIENCES & BIOENGINEERING SCIENCES

The Research Group

Software Languages Lab

has the honor to invite you to the public defense of the PhD thesis of

Carmen Torres Lopez

to obtain the degree of Doctor of Sciences

Title of the PhD thesis:

Advanced Debugging Techniques to Handle Concurrency Bugs in Actor-based Applications

Promotor:
Prof. dr. Elisa Gonzalez Boix

The defense will take place on

Monday, June 28, 2021 at 16h00

The defense can be followed through a live stream. Contact Carmen.Torres.Lopez@vub.be for more information

Members of the jury

Prof. dr. Beat Signer (VUB, chair)
Prof. dr. Viviane Jonckers (VUB, secretary)
Prof. dr. ir. Kris Steenhaut (VUB)
Prof. dr. Philipp Haller (KTH Royal Institute of Technology, Sweden)
Dr. Stephane Ducasse (INRIA Lille, France)

Curriculum vitae

Carmen Torres Lopez obtained her degree of Master in Computer Science from the Central University of Las Villas, Cuba, in 2016.
Subsequently, in 2016, Carmen started a PhD at the Software Languages Lab (SOFT) at the Vrije Universiteit Brussel (VUB).
Her work has been focused on the design and implementation of debugging techniques that aid developers of actor-based applications to identify the root cause of concurrency bugs.
Her research resulted in three scientific publications in peer-reviewed journals and conferences.

Abstract of the PhD research

With the advancements of multicore hardware, concurrent and parallel programming has become an essential part of software development. The actor model is an attractive foundation for developing concurrent applications because they can avoid data races by design since actors are isolated concurrent entities that do not share state. However, actor-based programs are not immune to concurrency bugs. Unfortunately, the non-deterministic behavior of concurrent programs makes it hard to reproduce bugs. Besides, the mere presence of a debugger can affect the program's behavior, a condition known as the probe-effect.
This dissertation explores the design and implementation of advanced online debugging techniques for actor-based programs. First, we created a taxonomy of concurrency bugs that can occur in actor-based programs. Using this taxonomy, we classified concurrency bugs found in the literature of actor-based programs. This systematic study drives our exploration of debugging techniques to aid the process of finding the root cause of concurrency bugs.
Second, we proposed catalogs of breakpoint types on messages, and stepping operations which combine sequential and message stepping. We implemented such message-based breakpoints and stepping operations with visualizations for message causality and asynchronous stack traces in Apgar, a proof of concept debugger for SOMns programming language in IntelliJ IDE. To evaluate the proposed debugging techniques in Apgar, we conducted a user study following an experimental research design.
Third, we explore a novel technique to build probe-effect free debuggers called multiverse debugging. Multiverse debugging is a new approach for debugging non-deterministic programs that allows developers to observe all possible execution paths of a parallel program and debug it interactively. We implemented Voyager, a proof of concept multiverse debugger based on a formal operational semantics of an actor-based language. Finally, we provide a proof of non-interference, i.e., we prove that observing the behavior of a program by the debugger does not affect the behavior of that program and vice versa.