About Verification Techniques of Cyber-Physical Systems

Besik Dundua[1], Tata Dundua[2], Mikheil Rukhaia[3]
[1]I.Vekua Institute of Applied Mathematics, and Kutaisi International University, Georgia
email: bdundua@gmail.com
[2]I.Vekua Institute of Applied Mathematics, Tbilisi, Georgia
email: tdundua9@gmail.com
[3]I.Vekua Institute of Applied Mathematics, Tbilisi, Georgia
email: mrukhaia@logic.at

Cyber-Physical Systems, shortly CPS, are networks of controllers that interact or control physical environments. Some examples of CPS are cars, aircrafts, railway systems, smart traffic systems, and the like. Such systems are becoming very complex and hard to get right, and are very expensive to develop and certify. It is very important, that CPS behaves correctly and securely, and only formal mathematical methods can provide strong guarantees about system correctness and security. These features must be established as early as possible in the CPS development process, it should be part of the design. Implementing a system with a flawed design can have catastrophic consequences. A recent example of this is the Boeing 737 max design flaw, that caused several aircraft crashes.

The mathematical modeling and analysis of modern CPS is very challenging for the following reasons:

- the need for advanced control programs combined with physical environments
- CPS are real-time systems whose controllers have to interact with each other and their environments in a timely manner
- distributed nature of CPS leads to combinatorial explosion in the number of different system behaviors that must be analyzed
- the need to deal with network delays, imprecise local clocks, etc.

It is obvious that an expressive mathematical formalism is needed to model modern CPS with their advanced control programs. A candidate for such formalism can be rewriting logic – a simple, general and expressive logic for distributed systems, whose modeling and analysis is supported by the Maude language and tool. In this talk we will speak about different approaches to use the Maude programming language and the Lingua Franca framework for verification of CPS. We underline some difficulties in this process and techniques to overcome them.