Semantics and Compilation of Synchronous Dataflow Languages

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Abstract

This internship offers to specify the semantics and formalize the compilation of a synchronous dataflow language. It will take place in the Whisper team of INRIA Paris – LIP6, located at University Paris 6, and will be supervised by Pierre-Évariste Dagand (CNRS).

Synchronous dataflow languages \([2, 6]\) are commonly used to implement reactive systems. Unlike usual software, a reactive system interacts directly with the physical world: it continuously receives inputs from its environment (e.g. through sensors), to which it must react by performing actions (e.g. through actuators). A dataflow language offers abstractions suited to manipulate and produce infinite streams of events. As a result, a synchronous dataflow program must go through a series of compilation passes before yielding an imperative program that can be efficiently executed on a computer.

Internship objectives: This project aims at developing a certified Lustre compiler in the Coq proof assistant \([7]\), taking inspiration from existing synchronous dataflow compilers \([1]\) and building upon the Compcert \([4]\) certified C compiler. It encompasses the following aspects:

- Specifying a synchronous dataflow semantics in Coq;
- Implementing compilation passes as Coq programs, translating dataflow programs to imperative ones;
- Proving that the semantics of dataflow programs is preserved through compilation.

Being broad in scope, this project offers many opportunities for in-depth experiments as well as in-the-large developments, depending on the student’s interest.

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Student’s profile: Acquaintance with an interactive theorem prover (Coq, or Isabelle) is recommended. Nonetheless, a motivated student with a strong background in functional programming (OCaml, or Haskell) could certainly learn to use Coq along the way \([2, 3]\). No prior knowledge of a synchronous programming paradigm is expected: the development of the formal semantics in a proof assistant shall provide many opportunities to deepen one’s understanding of the formalism.
References


