Formal analysis and implementation of the Faust programming language

Imré Frotier de la Messelière[1]

PhD advisor : Pierre Jouvelot[1]

PhD co-advisor : Jean-Pierre Talpin[2]

[1]MINES ParisTech, CRI - Center for computer science

[2]INRIA, IRISA

May 2014

Faust : Functional Audio Stream

- Domain specific language (DSL) dedicated to signal processing.
- Strictly functional programming paradigm.
- Faust program = description of a signal processor.
  - Input : Group of signals.
  - Output : Group of signals.
- Fully compiled programs (target language : C++).
- Use of a blocks diagram representation.

First formal analysis

- Definition of the precise semantics of the language core instruction set.
- First attempt at characterizing the language key semantic properties (typing, synchronicity).

General goal

- Extend the existing formal definitions of the language core to the whole language.
- Extend and generalize the existing theorems regarding Faust mathematical properties.
- Implement within the Faust compiler the analyses developed above in order to provide even more performant implementations (sequential, parallel) of Faust programs.

Tracks of study

- Optimization of the Faust compiler.
- Creation of a static typing system in order to :
  - find type errors during compilation.
  - get a compiled code that runs faster,
  - and thus make Faust more reliable and efficient.
- $\Longrightarrow$ Type inference algorithm.

Interest and stakes for Faust

- Optimization of the Faust compiler, used internationally and in various domains.
- Static typing $\Longrightarrow$ Safety.
  - Approximations for the cases of undecidability during type checking.
  - Handling of intervals, currently simplified during induction.
- Proof of currently conjectured properties of Faust programs.
- Handling of the macro-expansion problem of the multirate version of Faust.

General scientific contributions

- Introduction of static typing $\Longrightarrow$ Type inference.
- Undecidability solving $\Longrightarrow$ Constraints.
- Handling of intervals $\Longrightarrow$ Abstract interpretation.
- Synchronous system combining type inference, constraints and abstract interpretation.