Axioms for Control Operators in the CPS Hierarchy
- Short Summary -

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Each high-level programming language has its own set of control operators.

- Loop, recursion etc. in many languages.
- “go to” or jump in low-level languages.
- exception mechanism (Java’s try-catch-finally, Lisp’s catch/throw)
- continuation (Scheme’s call/cc, Ruby’s callcc)

Study on control operators is necessary:

- to have good structure of programs (to avoid “spaghetti” program.)
- to understand the semantics of programs, and to analyze/verify/transform programs.
Continuation is a notion which represents the rest of computation.

- \(([] + 3) \times 4\) is the continuation of \(1 \times 2\) in the expression \((1 \times 2 + 3) \times 4\)
- where \([]\) represents the current computation.
- By controlling continuations, we can control the execution sequence of programs.

Delimited Continuation is a notion which represents part of the rest of computation.

- \([] + 3\) is a delimited continuation of \(1 \times 2\) in the expression \((1 \times 2 + 3) \times 4\) up to the parenthesis.
- Or, Delimited continuations is a fragment of continuations.

**Theorem**

*We can represent all the control effects in terms of delimited continuations.*
Compilation of Programs

Typical Process of Compilation

"Modern" Compilation
Our question.

Question 1. Can we optimize programs in high-level languages sufficiently, or, in the same way as the optimization for intermediate languages?

The above question can be rewritten to:

Question 2. Can we identify a set of equations for high-level languages which has the same power as that for intermediate languages?
We have identified a set of equations for delimited-continuation control operators shift/reset (and its generalized ones) that satisfies:

- **soundness**: it is safe to use the equations for optimization.
- **completeness**: the equations are sufficient to optimize high-level programs with control operators.

The equations are very simple, thus “usable” for optimization of programs.

Our message: delimited-continuations are not too complex; they are usable control operators.