Macrolop Specification

Temirkhan Myrzamadi (a.k.a. Hirrolot)

November 17, 2020

Abstract

Macrolop [2] is a metalanguage on top of the standard C preprocessor aimed at language-oriented programming. It provides both the means to express intention in terms of domain-specific languages and a way to extend C with new programming language constructs, leading to a clearer and safer design of APIs. One example is typext4c [4], a header-only library implementing various type system extensions.

The two main characteristics of this project are:

- **Embedded.** Macrolop is implemented as a set of standard-compliant C99 macros, therefore it can be embedded directly in `*.c`/`*.h` source files without introducing third-party code generators.
- **General recursion.** The recursion mechanism is explicitly blocked by the standard [5]. Contrary to Boost/Preprocessor [1], Macrolop provides general recursion as-is (up to a certain limit, see 3).

This document describes the formal syntax and semantics of the metalanguage. See the official documentation [3] for the accompanied standard library.

Contents

1 EBNF Grammar

```
<eval> ::= "MACROLOP_EVAL(" { <term> }* ")" ;

<term> ::= "call(" <op> "," { <term> }* ")"
         | "v(" <preprocessor-token-list> ")" ;

<op>   ::= <ident> | { <term> }+ ;
```

Figure 1: Grammar rules

A metaprogram in Macrolop consists of a (possibly empty) sequence of terms, each of which is either a macro call or just a value.

Notes:

- The grammar above describes metaprograms already expanded by the C preprocessor, except for `MACROLOP_EVAL`, `call`, and `v`.
- `call` accepts `op` either as an identifier or as a non-empty sequence of terms that reduces to an identifier.
- `call` accepts arguments without a separator.

2 Notations

Notation 1 (Sequences)

1. *A sequence has the form* $(x_1, \ldots, x_n)$.
2. $()$ *denotes the empty sequence.*
3. *An element can be appended by comma: if* $a = (1, 2, 3)$ *and* $b = 4$*, then* $a, b = (1, 2, 3, 4)$.
4. *`seq-extract` extracts elements from a sequence without a separator:* `seq-extract((a, b, c)) = a b c`.
5. *`seq-comma-sep` extracts elements from a sequence separated by comma:* `seq-comma-sep((a, b, c)) = a, b, c`.

3 Reduction Semantics

We define reduction semantics for Macrolop. The abstract machine executes configurations of the form $\langle k; acc; control \rangle$:

- k is a continuation of the form $\langle k; acc; control \rangle$, where *control* include the ? sign, which will be substituted with a result after a continuation is called. For example: let $k = \langle k'; (1, 2, 3); v(abc)\ ? \rangle$, then $k(v(ghi))$ is $\langle k'; (1, 2, 3); v(abc)\ v(ghi) \rangle$. A special continuation *halt* terminates the abstract machine with provided result.
- *acc* is an accumulator, a sequence of already computed results.
- *control* is a concrete sequence of terms upon which the abstract machine is operating right now. For example: `call(FOO, v(123) v(456)) v(w 8) v(blah)`.

And here are the computational rules:

$$
\begin{array}{rl}
(v) : \langle k; acc; v(\overline{tok})\ term\ \overline{term'}\rangle & \rightarrow_1 \langle k; acc,\ \overline{tok}; term\ \overline{term'}\rangle \\
(v\text{-}end) : \langle k; acc; v(\overline{tok})\rangle & \rightarrow_1 k(seq\text{-}extract(acc, \overline{tok})) \\
(op) : \langle k; acc; call(\overline{term}, \overline{a})\ \overline{term'}\rangle & \rightarrow_1 \langle\langle k; acc; call(?, \overline{a})\ \overline{term'}\rangle; (); \overline{term}\rangle \\
(args) : \langle k; acc; call(ident, \overline{a})\ \overline{term}\rangle & \rightarrow_1 \langle\langle k; acc; ident(seq\text{-}comma\text{-}sep(?))\ \overline{term}\rangle; (); \overline{a}\rangle \\
(start) : MACROLOP\_EVAL(\overline{term}) & \rightarrow_1 \langle halt; (); \overline{term}\rangle
\end{array}
$$

Figure 2: Computational rules

Notation 2 (Reduction step; concrete sequence; meta-variables)

1. $\rightarrow_1$ *denotes a single step of reduction (computation).*
2. $\overline{x}$ *denotes a concrete sequence* $x_1 \ldots x_n$*. For example:* `v(abc) call(FOO, v(123)) v(u 8 9)`*.*
3. `tok` *denotes a single C preprocessor token,* `term` *is a term defined by the grammar,* `a` *is a term used as an argument.*

Notes:

- A body of a macro called using `call` must follow the grammar of Macrolop, otherwise it might result in a compilation error.
- With the current implementation, at most 2^{14} reduction steps is possible. After exceeding this limit, compilation will likely fail.

References

[1] Boost. *Boost/Preprocessor*. URL: `http://boost.org/libs/preprocessor`.

[2] Temirkhan Myrzamadi. *Language-oriented programming in C*. URL: `https://github.com/Hirrolot/macrolop`.

[3] Temirkhan Myrzamadi. *The Macrolop standard library documentation*. URL: `https://hirrolot.github.io/macrolop/`.

[4] Temirkhan Myrzamadi. *Type system extensions for C*. URL: `https://github.com/Hirrolot/typext4c`.

[5] Brian Tompsett. *Is the C99 preprocessor Turing complete?* URL: `https://stackoverflow.com/questions/3136686/is-the-c99-preprocessor-turing-complete`.