i4 Reading Group, April 01, 2016

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The Love/Hate Relationship with the C Preprocessor: An Interview Study

29th European Conference on Object-Oriented Programming (ECOOP 2015)

Valentin Rothberg
`https://www4.cs.fau.de/~vrothberg/`

The Authors

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The Conference: ECOOP

European **C**onference on **O**bject-**O**riented **P**rogramming

- Annual conference since 1986 (Paris)
- OOP **systems**, **languages** and **applications**
- Wide range of topics, tracks, workshops etc.
- Sister conference in North America: OOPSLA

"Historically ECOOP has combined the presentation of academic papers with comparatively practical experience reports, panels, workshops and tutorials."

ECOOP 2016: The Workshop Armada

11 workshops on various topics:

- Context-Oriented Programming
- Formal Techniques for Java-like Programs
- The Grace Programming Language
- Implementation, Compilation, Optimization of Object-Oriented Languages, Programs and Systems
- Aliasing, Capabilities and Ownership
- Tools for JavaScript Analysis
- Live Programming Systems
- Programming Models and Languages for Distributed Computing
- Programming Experience
- Script To Program Evolution
- Runtime Verification

Paper Overview

Problem statement:

- The C Preprocessor (CPP) has received strong criticism
  - Lack of separation of concerns
  - Error proneness
  - Obfuscation of source code
- Academia proposed alternatives
  - Syntactical preprocessors
  - Aspect-oriented programming
- Developers are continuously using CPP

Core question:

- How do practioners (i.e., "real world") perceive the CPP?
- <u>In other words:</u> Are we (i.e., academia) on the right track?

Before discussion, let’s summarize the paper

An Interview Study

Study setup:

- Interview of 40 developers
- Cross validation with
  - a survey among 202 developers
  - results mined from software repositories
  - prior studies

"Our study is designed to elicit the *perception* of developers by talking to them."

RQ1: Why is the CPP still widely used in practice?

- **Portability**
  support multiple platforms and systems
- **Variability**
  alternative or optional implementations, features, modules
- **Code optimizations**
  highly compiler-dependent
- **Code evolution**
  grace period for deprecated code
- **Language limitations**
  include guards

RQ2: What do developers consider as alternatives to CPP directives? (1)

Guidelines for structuring code

- Too diverse answers in interview
- Question has been moved to survey

```
void function (){

#ifdef OS1
  /* Code 1 here.. */
#endif

#ifdef OS2
  /* Code 2 here.. */
#endif

}
```

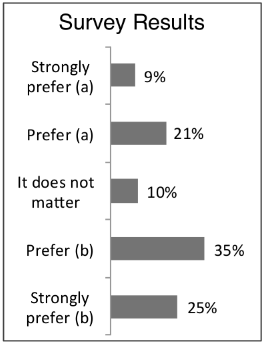
(a)

```
// FILE: OS1.c
void function (){
  /* Code 1 here.. */
}

// FILE: OS2.c
void function (){
  /* Code 2 here.. */
}
```

(b)

In (b), only OS1.c or OS2.c is compiled depending on the platform. It is controlled at makefile level.

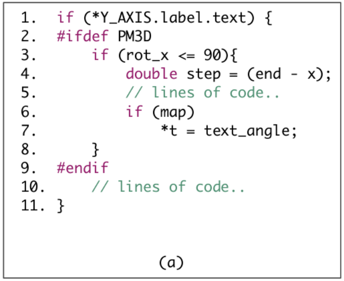


RQ2: What do developers consider as alternatives to CPP directives? (2)

In-Language runtime mechanisms:

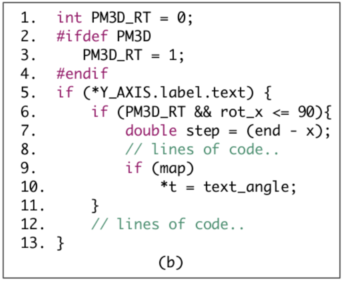
- Use runtime bindings (e.g., if statements)
- Diverse opinions:
  - As much as possible
  - As few as possible (scaling)

“Surprising” results?



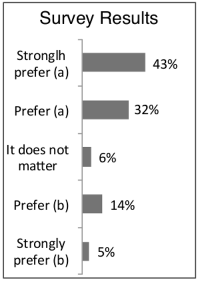
```
if (*Y_AXIS.label.text) {
#ifdef PM3D
     if (rot_x <= 90){
          double step = (end - x);
          // lines of code..
          if (map)
               *t = text_angle;
     }
#endif
     // lines of code..
}
```

(a)



```
int PM3D_RT = 0;
#ifdef PM3D
    PM3D_RT = 1;
#endif
if (*Y_AXIS.label.text) {
     if (PM3D_RT && rot_x <= 90){
          double step = (end - x);
          // lines of code..
          if (map)
               *t = text_angle;
     }
     // lines of code..
}
```

(b)



RQ2: What do developers consider as alternatives to CPP directives? (3)

No alternative or general replacement:

- Sometimes code **must** be removed
- Alternatives would end-up as a CPP
- Using CPP is **portable**

RQ3: What are common problems of using CPP directives in practice? (1)

Preprocessor related bugs:

- Incorrect macro expansion
- Misspelled macro names
- Missing/undefined variables and functions
- Syntax and linking errors
- Behavioral changes due to macro interactions
- Memory and resources leaks
- Memory corruption and race conditions, ...

"[...] code that does not compile is easy to deal with, but the runtime bugs are the harder ones to detect."

RQ3: What are common problems of using CPP directives in practice? (2)

Combinatorial testing:

> “[...] code that does not compile is easy to deal with, but the runtime bugs are the harder ones to detect.”

- Finding the configuration(s) is not trivial
- “Combinatorial explosion”
- The more macros, the bigger the testing matrix

Solution?

- Check only a few configurations
- Check only a default configuration (optionals activated)
- Different compilers on different platforms

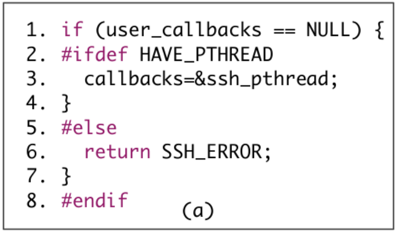
RQ3: What are common problems of using CPP directives in practice? (3)

Code comprehension:

- Harder to read and understand
- Mix of languages:
  - C/C++ (if, else, for, while, switch)
  - CPP (#ifdef,#ifndef,#elif)
- Deep nesting of #ifdef blocks

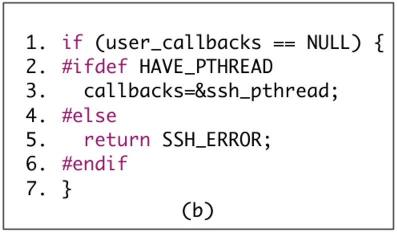
RQ4: Do developers care about the discipline of preprocessor annotations?

- **Yes**: impact on code quality
- Some (would) use it but document their intentions
- Refactoring: “I am not going to touch that” :-)



```
if (user_callbacks == NULL) {
#ifdef HAVE_PTHREAD
  callbacks=&ssh_pthread;
}
#else
  return SSH_ERROR;
}
#endif
```

(a)



```
if (user_callbacks == NULL) {
#ifdef HAVE_PTHREAD
  callbacks=&ssh_pthread;
#else
  return SSH_ERROR;
#endif
}
```

(b)

Repository mining:

- 21 (7%) of 299 developers introduced 85% of undisciplined annotations
- “[...] some got defensive and excused”

Conclusion and Implications for Practitioners and Researchers

Guidelines and enforcement:

- It's done for good reasons
- Only few tools to enforce CPP related guidelines

Quality assurance:

- Configurations are rarely tested systematically or even exhaustively
- Systematic sampling and family-based analyses are promising directions

Tool design and technology transfer:

- CPP's portability makes alternatives hard to establish
- Research should communicate better

What we should keep in mind (imho):

- Love it or hate it: the CPP will be around
- Plenty of research has happened, but we're not done (yet)
- Investing into new research/tools will pay off
- Alternatives to CPP will be hard to establish

Next time on ...

Paul A. Karger, and Roger R. Schell
Thirty Years Later: Lessons from the Multics Security Evaluation
Proceedings of the 18th Annual Computer Security Applications Conference (ACSAC '02)

by
Christian Dietrich
`https://www4.cs.fau.de/~stettberger/`