Type Flattening Obfuscation

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***Abstract*—Beside data and control flow, high-level types are important in binary code analysis, particularly in decompilation. Some research papers have introduced methods to map machine-dependent objects into types of some C-like type system. For the anti-decompilation/obfuscation purpose, we present a novel technique which bypasses existing type recovery approaches. We have implemented a prototype obfuscating C compiler to demonstrate the technique, the compiler is given open source.**

***Index Terms*—type recovery, decompilation, obfuscation**

1. Introduction

Binary code *decompilation* [1] is to transform the low-level, machine-dependent code of a program into a high-level form, like code of a high-level language. In almost all academic research papers and commerical products, the target language is C. Similar to compilers, a modern binary code decompiler consists of many phases [1, 5]: disassembly, function boundary detection, immediate representation (IR) lifting, control-flow graph (CFG) recovery, high-level variables detection, type (i.e. variable types and function signatures) recovery, etc. Each phase requires particular but not independent [3] analysis techniques: the results of a phase can affect another phase. The analyzed program is transformed gradually into a higher-level, more abstract and more understandable representation.

In the opposite direction, binary code *obfuscation* is a method to protect the low-level code from being decompiled, or from being analyzed in general. Because the code analysis contains of different interdependent phases, the obfuscation [7, 16] can proceed at any of them, e.g. anti-disassembly (binary packer, self-modifying code), binary stripping, control-flow flattening, virtualization (for both data and control obfuscation)... just name a few. Basically, each obfuscation method consists of one or several *semantics-preserving* transformations [4, 7] which hide certain properties of the code.

An optional feature of binary code decompilation is *type reconstruction*, namely to recover high-level types from machine-dependent objects [2, 5]. This is the research objective of some research papers [9, 11, 13, 14], and killing feature of some commercial [19, 20] as well as open source [18] binary code analysis tools. Beside decompilation, types and particularly *function signatures* are also essential in numerous applications, e.g. static binary rewriting [8, 10] and raising [17], see for example [12] for a survey. Thus the knowledge about types expand the attack surface because more analysis can be applied on the programs need to be protected.

Despite of successes in type reconstruction and the need of protecting function signatures, to the best of our knowledge there is no explicit effort in protecting type information. This paper presents a method for type obfuscation, the principal ideas are that the compiler does not need to preserve all information about high-level types (type erasure), with specific tricks we can exploit the *semantics gap* between the high-level language and machine code to make some information very hard if not impossible to be recovered. We do not claim that all type information can be hidden, the attacker can eventually know some but it is not possible to distinguish the concrete underlying types from one to another, thus the proposed notion of *type flattening*.

The ideas are implemented in *uCc*, an open source obfuscating C compiler which obfuscates function signatures. Our goal is to make functions in binaries generated by *uCc* can be perfectly analyzed by classical procedures (boundary detection, disassembling, CFG recovery, etc), only their signatures are obfuscated. By that way, we can exclusively evaluate the effectiveness of type obfuscation tricks. We have found that Mixed Boolean Arithmetic (MBA) expressions [6, 15] are very useful for the goal.

1.1. Contributions

In summary, the paper makes the following contributions:

2. Brief history of binary type inference

3. Ease of Use

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TABLE 1. TABLE TYPE STYLES

Table Head	Table Column Head		
	Table column subhead	*Subhead*	*Subhead*
copy	More table copy[a]		

[a]Sample of a Table footnote.

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Figure 1. Example of a figure caption.

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