Type Flattening Obfuscation

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Abstract. Beside data and control flow, high-level types are also important in program analysis, indeed type recovery is an essential step in binary code decompilation. For the purpose of anti-decompilation, the paper introduces a novel obfuscation technique which makes types become harder to be reconstructed.

1 Introduction

An important step in binary code *decompilation* [1] is to detect high-level objects (e.g. functions, variables) from low-level machine dependent objects [2] (e.g. registers, raw memory accesses, machine instructions) before annotate them with types of the supposed original language. Because most of information about high-level types is lost in compilation, the binary code *type recovery* requires special techniques, a survey up until 2015 can be referenced in [5].

In the opposite direction, binary code *obfuscation* is to make the decompilation (or in general code analysis) harder. Since the data and control flow are principal elements for the program analysis, current obfuscation techniques [4] focus mostly on them. But to the best of our knowledge, there is still no explicit effort in obfuscating high-level types. There would be several reasons for this lack of effort.

First, type obfuscation is unsurprisingly a side effect of data or control flow obfuscation. Indeed, type recovery algorithms need both data and control flow to build type constraints, if any of them is hidden then the algorithms cannot work correctly. Or if the function boundary is not found (because of anti-disassembing tricks, for example), then high-level objects cannot be recognized. *Second*, high-level types seem too coarse to be worthy of being protected, in many cases just knowing certain values of the input which make the program exploitable is enough. But knowledge about types expands attack surfaces because more analysis can be proceeded, beside decompilation see the survey [5] for a more complete list.

2 Type flattening compiler

We present *uCc*, an open source C compiler that explicitly obfuscates high-level types. The compiler is implemented in Rust, its source code and a short user guide are given at (cite). Our effort is to attack the core of type recovery algorithms, these are the data flow used to build type constraints, and the *semantic* *gap* between types in the high-level language and their representations in the low-level machine code. Beside custom tricks, *uCc* uses extensively obfuscation transformations based on Mixed Boolean Arithmetic expressions [3, 6]. To make some code diversity, the compiler is *probabilistic*: given a source code, *uCc* generates each time a different (but computationally equivalent) output machine code.

We test outputs of *uCc* against some decompilers, table 1 describes briefly tested functions and their types in source code, table 2 shows results of using decompilers to decompile binaries generated by *uCc*. The test suite is also available at the repository.

Table 1. Functions and original types

Description	Function type
identity	`int id(int)`
division	`int div(short, char)`
modular	`int mod(int)`
increase pointer then dereference	`int inc_deref(int*)`

Table 2. Type flattening effect

Original type	Hex-Rays	JEB	Ghidra	Snowman
`int id(int)`	`int64 id(int64)`	`ulong id(ulong)`	`ulong id(void)`	`int64 id(int64)`
`short div(short, char)`	`int64 div(uint64, uint64)`	`div_t div(int, int)`	`div_t div(int, int)`	`int64_t div(int64, int64)`
`char mod(short, char)`	`int64 mod(int64, int64)`	`ulong mod(ulong, ulong)`	`ulong mod(void)`	`int64 mod(int64, int64)`
`int inc_deref(int*)`	`int64 inc_deref(int64)`	`ulong inc_deref(ulong)`	`ulong inc_deref(undefined8)`	`int64 inc_deref(uint64)`

References

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