The Pennsylvania State University

The Graduate School

College of Engineering

TURING MACHINE ENCODING OBFUSCATION

A Thesis in

Information Science and Technology

by

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Submitted in Partial Fulfillment

of the Requirements

for the Degree of

Master of Science

May 2017

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Abstract

Internet provides people all kinds of information and opportunities, however, it also provides chances for hackers to spread their malwares to end users all over the world.

Software obfuscation is a crucial research field due to the severe computer security situation of Internet era. Usually we try to make programs more explicit and clearer for people to read while software obfuscation focuses on complicating source programs to make it difficult or even impossible for attackers to do reverse engineering so that malicious codes and software vulnerabilities are constrained from spreading.

In this paper we proposed a novel method to do software obfuscation. In source codes, control flow graph was changed with the help of Turing machine encoding. Predicates which are determinative for the control flow traversing in source codes are transformed to different Turing machines. These encoded Turing machines will be interpreted by an universal Turing machine when executed. Hence, control flow graph could be complicated to a great extent by leveraging this transformation. Software is obfuscated through this Turing machine encoding and connecting segmented source programs with Turing Machine models. This paper articulate our Turing machine obfuscation in detail and demonstrate the effectiveness through large volume of experiments.

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Dedication

Chapter 1 |
Introduction

1.1 Software Obfuscation

Software Obfuscation is an important cryptographic concept with wide applications.However until recently there [1] was little theoretical investigation of obfuscation, despite the great success theoretical cryptography has had in tackling other challenging notions of security [2].

Usually we would like our source codes to be readable while software obfuscation research does exactly the opposite process which harden the understanding process or make it even impossible. The final goal of conducting software obfuscation is to hide those classified or sensitive information which could be extracted by some reverse engineering means and at the same time preserving softwareâĂŹs functionality. We can always treat obfuscation method as a virtual black box or a compiler which could transform the primitive source code to instrumented codes that will behave exactly the same as the original codes. Which means, the obfuscated programs will yield outputs the same with the original out- puts given identical inputs. [3]

1.1.0.1 Obfuscation Benefits

There are many reasons to obfuscate source codes. Software obfuscation could help companies or individuals protect their intellectual property from being theft. With the development of distributed system and cloud computing, more and more users begin to store data on public web services like Amazon Web Service, it induces privacy leak risk which would do huge damage to Internet community if not dealt

properly. Obfuscation could exert great influence on protect end users' privacy. Another big battle filed of software obfuscation is to compete with the dark side of the software security - Hackers. Hackers do a lot harm to the world exploiting vulnerabilities of software every year. On important step to hack victims' system is to reverse engineer the software binaries and figure out the logic of it. Although an experienced hacker could always reverse engineer a software given enough time and energy, software obfuscation could make this extremely hard.

1.2 Obfuscation Research Situation

In early days, most obfuscation protection systems encrypt the code and then decrypt it at the application's startup. This method is easy to implement while it is also risky and could be easily deobfuscated if an hacker figured out the encryption algorithm.

Chapter 2
Title of the Second Chapter

2.1 Introduction

When in the Course of human events, it becomes necessary for one people to dissolve the political bands which have connected them with another, and to assume among the powers of the earth, the separate and equal station to which the Laws of Nature and of Nature's God entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to the separation.

2.2 More Declaration

We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness. –That to secure these rights, Governments are instituted among Men, deriving their just powers from the consent of the governed, –That whenever any Form of Government becomes destructive of these ends, it is the Right of the People to alter or to abolish it, and to institute new Government, laying its foundation on such principles and organizing its powers in such form, as to them shall seem most likely to effect their Safety and Happiness. Prudence, indeed, will dictate that Governments long established should not be changed for light and transient causes; and accordingly all experience hath shewn, that mankind are more disposed to suffer, while evils are sufferable, than to right themselves by abolishing the forms to which they are accustomed. But when a long train of abuses and usurpations, pursuing invariably the same Object evinces

a design to reduce them under absolute Despotism, it is their right, it is their duty, to throw off such Government, and to provide new Guards for their future security. –Such has been the patient sufferance of these Colonies; and such is now the necessity which constrains them to alter their former Systems of Government.

$$x = y \tag{2.1}$$

The history of the present King of Great Britain [George III] is a history of repeated injuries and usurpations, all having in direct object the establishment of an absolute Tyranny over these States. To prove this, let Facts be submitted to a candid world.

Chapter 3
Title of the Third Chapter

3.1 Introduction

When in the Course of human events, it becomes necessary for one people to dissolve the political bands which have connected them with another, and to assume among the powers of the earth, the separate and equal station to which the Laws of Nature and of Nature's God entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to the separation.

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Chapter 4
Title of the Fourth Chapter

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When in the Course of human events, it becomes necessary for one people to dissolve the political bands which have connected them with another, and to assume among the powers of the earth, the separate and equal station to which the Laws of Nature and of Nature's God entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to the separation.

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4.2.1 Some nonsense here

But when a long train of abuses and usurpations, pursuing invariably the same Object evinces a design to reduce them under absolute Despotism, it is their right, it is their duty, to throw off such Government, and to provide new Guards for their future security. –Such has been the patient sufferance of these Colonies; and such is now the necessity which constrains them to alter their former Systems of Government.

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The history of the present King of Great Britain [George III] is a history of repeated injuries and usurpations, all having in direct object the establishment of an absolute Tyranny over these States. To prove this, let Facts be submitted to a candid world.

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Appendix A
Title of the First Appendix

A.1 Introduction

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A.2.1 Some Subsection Title Here

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themselves by abolishing the forms to which they are accustomed. But when a long train of abuses and usurpations, pursuing invariably the same Object evinces a design to reduce them under absolute Despotism, it is their right, it is their duty, to throw off such Government, and to provide new Guards for their future security. –Such has been the patient sufferance of these Colonies; and such is now the necessity which constrains them to alter their former Systems of Government. The history of the present King of Great Britain [George III] is a history of repeated injuries and usurpations, all having in direct object the establishment of an absolute Tyranny over these States. To prove this, let Facts be submitted to a candid world.

Appendix B
Title of the Second Appendix

B.1 Introduction

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Appendix C
Title of the Third Appendix

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Appendix D
Title of the Fourth Appendix

D.1 Introduction

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D.2 More Declaration

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Bibliography

[1] Gul Agha, S. K. D. (2005) "CUTE: a concolic unit testing engine for C." in *ACM SIGSOFT Software Engineering Notes.*, p. Vol. 30. No. 5. ACM.

[2] Lynn, B., M. Prabhakaran, and A. Sahai (2004) "Positive results and techniques for obfuscation," in *International conference on the theory and applications of cryptographic techniques*, Springer, pp. 20–39.

[3] "TuringmachineSimulation," `http://turingmaschine.klickagent.ch/einband/`.

Vita

Yan Wang

The details of my childhood are inconsequential.