

**ANALYZING THE STACK-BASED BUFFER OVERFLOW
PROBLEM**

AHMAD NAZRI BIN ZAINOL

UNIVERSITI UTARA MALAYSIA 2008

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**ANALYZING THE STACK-BASED BUFFER OVERFLOW
PROBLEM**

**A thesis submitted to the
Division of Applied Sciences, College of Arts and Sciences
in partial fulfillment of the requirements for the degree of
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**By
Ahmad Nazri Bin Zainol**



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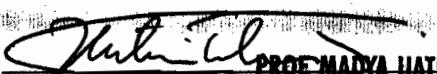
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ABSTRAK (BAHASA MELAYU)

Walaupun banyak penyelidikan telah dijalankan selama hampir lebih dari 20 tahun, masalah *buffer overflow* masih lagi berlaku hingga sekarang. Kajian ini mengambil peluang untuk menganalisa *buffer overflow* jenis *stack-based* yang merupakan satu jenis *buffer overflow* yang dominan. Satu demonstrasi eksperimen dalam persekitaran terkawal dijalankan untuk menunjukkan bagaimana dan kenapa masalah ini berlaku. Sepanjang demonstrasi ini, syarat-syarat utama kenapa dan bagaimana eksplotasi ini berlaku dikenalpasti, dianalisa dan didokumenkan. Hasil kajian ringkas ini menunjukkan bahawa terdapat banyak lagi yang boleh dilakukan terutamanya pada peringkat penulisan kod untuk mengelakkan masalah *buffer overflow* ini sebelum kerosakan berlaku, yang selalunya selepas produk perisian telah dijual. Dalam hal ini ianya sudah tentu membazir banyak sumber seperti kos, tenaga manusia dan masa. Hasilnya, beberapa cadangan yang praktikal telah kemukakan di mana ianya sesuai untuk perlaksanaan dan penyelidikan seterusnya. Selain dari itu, hasil kajian ini juga penting untuk dijadikan asas dalam merekabentuk dan melaksana kaedah atau mekanisma baru untuk mengesan dan mengelak masalah *buffer overflow*.

ABSTRACT

It is interesting to know that a buffer overflow problem still exist today despite of many researches have been conducted in a period of more than 20 years. This study takes an opportunity to analyze one of the dominant buffer overflow problem type, a stack-based buffer overflow. A controlled experimental demonstration has been carried out to emulate a stack-based buffer overflow exploit. During the process, main conditions why and how the exploit happens will be identified, analyzed and documented. The findings showed that more works can be done at the coding stage to prevent the problem before the damage (exploit) occurs which normally happen after the software product has been distributed. In this case more resources have been wasted such as cost, man-hour and time. Hence, several practical suggestions with its own advantageous have been highlighted for further research and implementation. In addition, the findings should be very useful inputs in designing and implementing new buffer overflow detection and prevention mechanisms.

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LIST OF ABBREVIATIONS

AMD	Advance Micro Device
ASLR	Address Space Layout Randomization
CERT	Computer Emergency Response Team
CPU	Central Processing Unit
CVE	Common Vulnerabilities and Exposures
DEP	Data Execution Prevention
DLL	Dynamic Link Library
EBP/ebp	extended base pointer
EIP/eip	extended instruction pointer
ESP/esp	extended stack pointer
GCC	GNU Compiler Collection
gdb	GNU Debugger
GOT	Global Offset Table
IDE	Integrated Development Environment
IDS	Intrusion Detection System
IEC	International Electrotechnical Commission
IOS	Internetwork Operating System
ISO	International Organization for Standardization
NOEXEC	No Execute
NOP	No Operation
NX	No Execute
OS	Operating System
POC	Proof-Of-Concept
SEH	Structured Exception Handling
SP	Service Pack
SQL	Structured Query Language
SSP	Stack-Smashing Protector
XD	Execute Disable

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CHAPTER ONE

INTRODUCTION

Almost 20 years after the first publicized buffer overflow vulnerability and exploit used by Morris worm in November, 1988 [1] then followed by Code Red worm in July 2001 [2] and Slammer worm [3] in January 2003, the buffer overflow still one of the top vulnerability, proven to have a severe effect, which has been exploited successfully. Since then, the buffer overflow vulnerable exploited again and again which cover a wide range of computer application, library, operating system (kernel and embedded system as well) and networking. There are many hardware and software based techniques and tools that have been proposed and developed to detect and protect from buffer overflow vulnerable. However this vulnerable still happen and based on the trend it look likes this problem will continue to happen.

It is publicly known that the buffer overflow happens when there is no bound checking on the used buffer in programs. In the plain source codes, this no bound checking is a normal for unsafe programming language that dominated by C and C++ for a set of the standard library functions. Unfortunately, C and C++ are the languages that most widely used for critical applications such as kernel, Operating System (OS), database engine and device driver.

A buffer is small and reusable temporary data storage during the program execution. Normally it is declared as sized array data type in C and C++ programs though it is not limited to the declared sized array because other unsafe standard C and C++ functions used for string and character manipulation such as `strcat()` and `gets()` also resembled similar characteristics. Without bound checking, input size that bigger than the declared size of the array will overwrite other adjacent data in memory and corrupting them. From the programmer point of view, the problem is, when we declared a sized array in a program, we normally already expected or pre-calculated the maximum number of input. However, we cannot accurately determine the maximum number of input from user and other application

The contents of
the thesis is for
internal user
only

Hopefully, by having a better understanding on how and why the stack-based buffer overflow vulnerability and exploit, programmer that using C or other similar 'unsafe language' can avoid this problem at the earliest stage of their task in developing a program. Having a good knowledge where the buffer overflow vulnerability is possible to happen in the application development for example, will obviously contribute something that can improve the product's quality, saving cost, man-hour and time. This is also supposed to be beneficial for other languages that use C as their base code so that the buffer overflow problem does not inherited and propagated.

5.2 Related Future Work

The information provided in this part is actually extracted from the Finding and Discussion section. One future research that can be done is to find the relationship between the program size and speed when we add extra code for buffer overflow protection. This should be specific to buffer overflow codes and should be critical for large program. The effectiveness of the prior secure coding knowledge or training also could be measured when the topics of secure C/C++ coding included in C/C++ syllabus or suitable secure coding training is conducted. This also can be applied when implementing a comprehensive exception handling in C/C++ programming.

Another interesting thing to explore is to enhance the C/C++ editor or compiler with educational info of the buffer overflow problem such as through the intellisense feature. Research can be done to gauge the effectiveness of the implementation on reducing the buffer overflow problem.

This project does not emphasize on the compile and runtime detection and prevention solution other than implementing a comprehensive exception handling because of the many researches (mostly funded) have been carried out as discussed in the Literature Review section. Although it is out of programmer's control, this does not mean it is not important. For example, the convention used for C function call, the way how the stack frame constructed and destroyed (also how the processor support the mechanism through its execution environment) may be reviewed and changed to the better and safer ways.

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