Secure Coding In C and C++

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Outline

- What is the problem with C

- Common string manipulation errors
- Mitigation strategies
- Detection and recovery

- Pointer subterfuge
- Mitigation strategies
- Reference

What is the problem with C

- Portability
  - Problem arise from an imprecise understanding of the semantics of these logical abstractions and how they translate into machine-level instructions.
  - The C programming language is intended to be a *lightweight* language with small footprint.
  - When programmers fail to implement required logic because they assume it is handled by C (but it is not), it leads to vulnerabilities.

What is the problem with C

- Lack of type safety
  - Preservation
    - Preservation dictates that if a variable x has type t and x evaluates to a value v, then v also has type t.
  - Progress
    - Evaluation of an expression does not get stuck in any unexpected way.
- Legacy code
  - Some insecurity function such as **strcpy()** are standard, they continue to be supported and developers continue to use them.

Common string manipulation errors

- The four most common errors are
  - Unbounded string copies
  - Off-by-one errors
  - Null termination errors
  - String truncation

Unbounded string copies

- The standard strcpy() and strcat() functions perform unbounded copy operations.

```
void main(void) {
        char Password[80];
        puts("Enter 8 character password:");
        gets(Password);
                …
}
```

```
int main(int argc, char *argv[]) {
        char name[2048];
        strcpy(name, argv[1]);
        strcat(name, "=");
        strcat(name, argv[2]);
                …
}
```

Off-by-one errors

```
int main(int argc, char *argv[]) {
        char source[10];                                   1.
        strcpy(source, “0123456789”);
        char *dest = (char *)malloc(strlen(source));
        for(int i=1; i<=11; i++) {                          2.
                dest[i] = source[i];
  3.    }
        dest[i]=‘\0’;                          4.
        printf(“dest = %s”,dest);
}
```

- 1.copy 11bytes,including a one-byte terminating null character.
- 2.strlen() does not account for the null byte.
- 3.first position in a C array is indexed by 0.
- 4.causes an out-of-bounds write.

Null termination errors

- A common problem with C-style strings is a failure to properly null terminate.

```
Int main(int argc, char *argv[]) {
        char a[16];
        char b[16];
        char c[32];

        strcpy(a, “0123456789abcdef”);
        strcpy(b, “0123456789abcdef”);
        strcpy(c, a);
        strcat(c, b);
        printf(“a = %s\n”, a);
        return 0;
}
```

String truncation

- String truncation occurs when a destination character array is not large enough to hold the contents of a string.

```
#include <iostream.h>
int main() {
        char buf[12];
        cin.width(12);
        cin >> buf;
        cout << “echo: “ << buf << endl;
}
```

String errors without functions

- Highly susceptible to error functions: strcpy(), strcat(), gets(), streadd(), strecpy(), strtrns().

```
int main(int argc, char *argv[]) {
        int i = 0;
        char buff[128];
        char *arg1 = argv[1];

        while(arg1[i] !='\0') {
                buff[i] = arg1[i];
                i++;
        }
        buff[i] = '\0';
        printf("buff = %s\n", buff);
}
```

Mitigation strategies

- Input validation

```
int myfunc(const char *arg) {
        char buff[100];
        if(strlen(arg) >= sizeof(buff)) {
                abort();
        }
}
```

Mitigation strategies

- Use fgets() and gets_s() instead of gets()
  - Never use gets().
  - fgets(buff, BUFFSIZE, stdin)
  - gets_s(buff, BUFFSIZE)
- Use memcpy_s() and memmove_s() instead of memcpy() and memmove()
  - Add an additional argument that specifies the maximum size of the destination.

Mitigation strategies

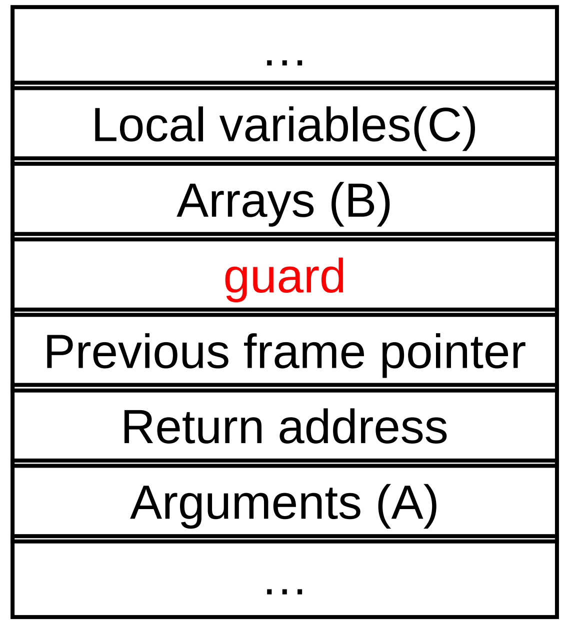
- Use strcpy_s() and strcat_s() instead of strcpy() and strcat()
  - strcpy_s() strcat_s() : only succeeds when the source string can be fully copied to the destination without overflowing the destination buffer.
  - strncpy() strncat() :
    - strncpy(dest, source ,dest_size – 1);
    - strncat(dest, source, dest_size-strlen(dest)-1);
  - strncpy_s() strncat_s()
  - strlcpy() strlcat()
    - size_t strlcpy(char *dst, const char *src, size_t size);
    - size_t strlcat(char *dst, const char *src, size_t size);

Detection and recovery

- Compiler generated runtime checks
- Nonexecutable stacks
- Stackgap
  - Introducing a randomly sized gap of space upon allocation of stack memory makes it more difficult for an attacker to locate a return value on stack.
- Runtime bound checkers
- Canaries
  - The canary is initialized immediately after the return address is saved and checked immediately before the return address is accessed.

Detection and recovery

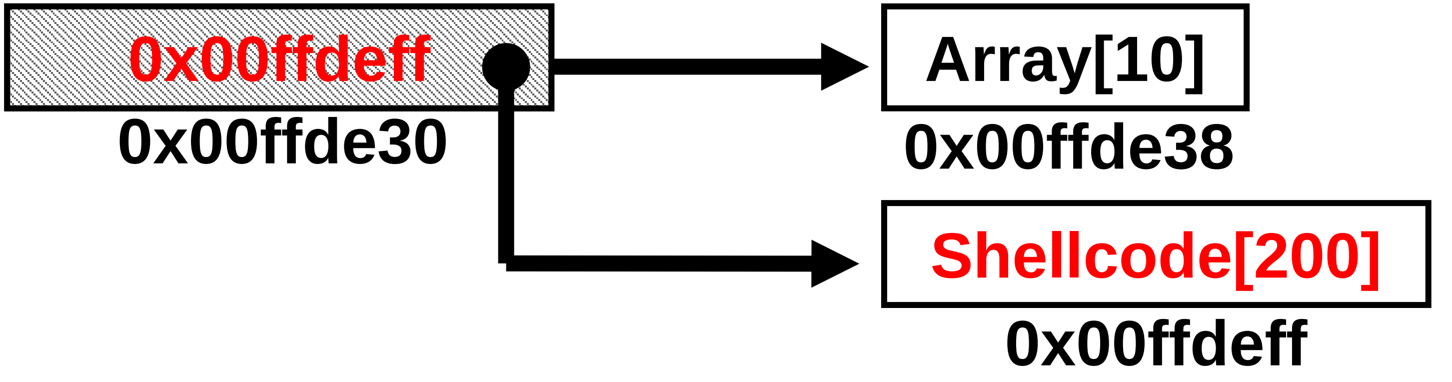
- Stack smashing protector
  - Check guard value while return.



Stack

- (A) no array
- (B) array
- (C) no array

Pointer subterfuge



Pointer subterfuge

- Data location
  - UNIX executables contain both a data and a BSS segment.
  - Data segment contains all initialized global variables and constants.
  - BSS segment contains all uninitialized global variables.
- Function pointers
- Data pointers

Pointer subterfuge

- Modifying the instruction pointer
  - The instruction pointer register (eip) contains the offset in the current code segment for the next instruction to be executed.
- Global offset table
  - ELF: the default binary format on Linux, Solaris 2.x and SVR4 is called the executable and linking format (ELF).
  - The process space of any ELF binary includes a section called the global offset table (GOT). The GOT holds the absolute addresses, making them available without compromising the position independence of, and the ability to share, the program text.

Pointer subterfuge

- Global offset table

```
%objdump –dynamic-reloc test-prog
Format:           file format elf32-i386

DYNAMIC RELOCATION RECORDS
OFFSET       TYPE                 VALUE
08049c0      R_386_GLOB_DAT       __gmon_start__
08049a8      R_386_JUMP_SLOT      __libc_start_main
08049ac      R_386_JUMP_SLOT      strcat
08049b0      R_386_JUMP_SLOT      printf
08049b4      R_386_JUMP_SLOT      exit
```

Pointer subterfuge

- The .dtors section

```
#include <stdio.h>
#include <stdlib.h>
static void create(void)
        __attribute__ ((constructor));
static void destroy(void)
        __attribute__ ((destructor));

int main(int argc, char *argv[]) {
printf(……
…
}
void create(void) {          …..       }
void destroy(void) {         …         }
```

Pointer subterfuge

- The .dtors section
  - 0xffffffff {function-address} 0x00000000

```
%objdump –s –j .dtors dtors

dtors:                    file format elf32-i386

Contents of section .dtors:
804959c ffffffff b8830480 00000000
```

Pointer subterfuge

- The atexit() and on_exit() functions
  - The atexit() function registers a function to be called without arguments at normal termination.
  - The atexit() function works by adding a specified function to an array of existing functions to be called on exit. When exit() is called, it invokes each function in the array LIFO order.

Pointer subterfuge

- The longjmp() function
- Exception handling

Mitigation strategies

- The best way to prevent pointer subterfuge is to eliminate the vulnerabilities that allow memory to be improperly overwritten.

Reference

- Secure Coding In C and C++

  - Robert C. Seacord Addison-Wesley
- Google (www.google.com)

Any question?