Security Vulnerabilities - Crash course

Holistic Software Security

Aravind Machiry

Stack Based Buffer Overflow

Stack Buffer Overflow

example2.c

```
void function(char *str) {
   char buffer[16];

   strcpy(buffer,str);
}

void main() {
  char large_string[256];
  int i;

  for( i = 0; i < 255; i++)
    large_string[i] = 'A';

  function(large_string);
}
```

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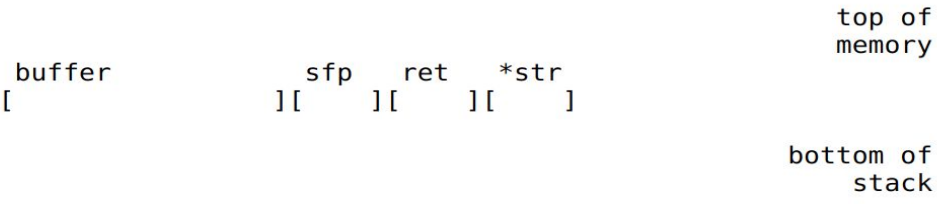

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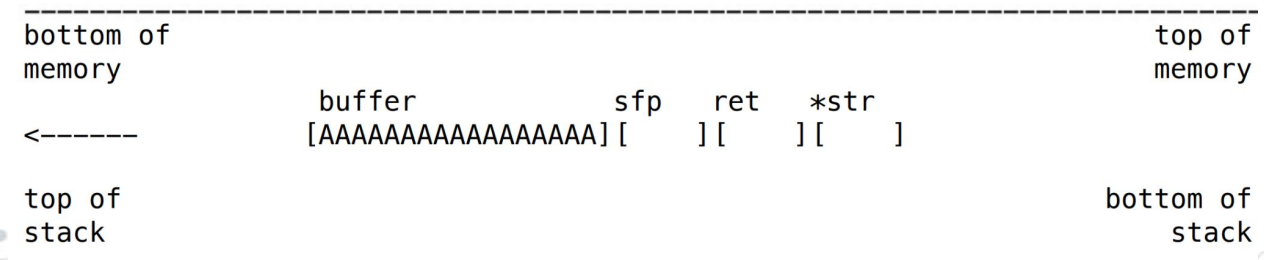

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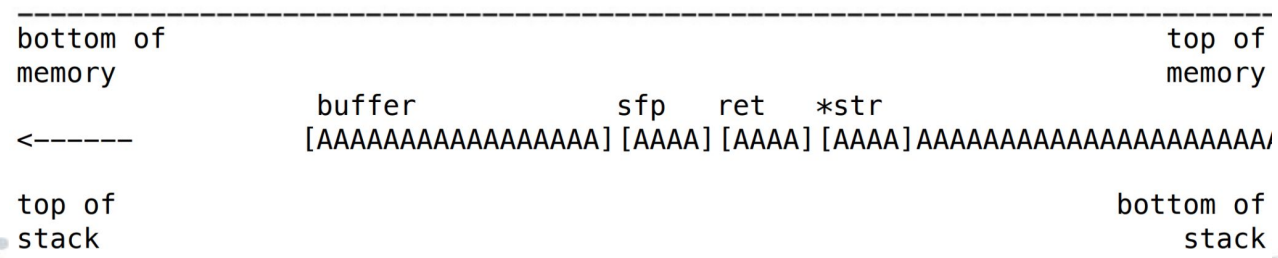

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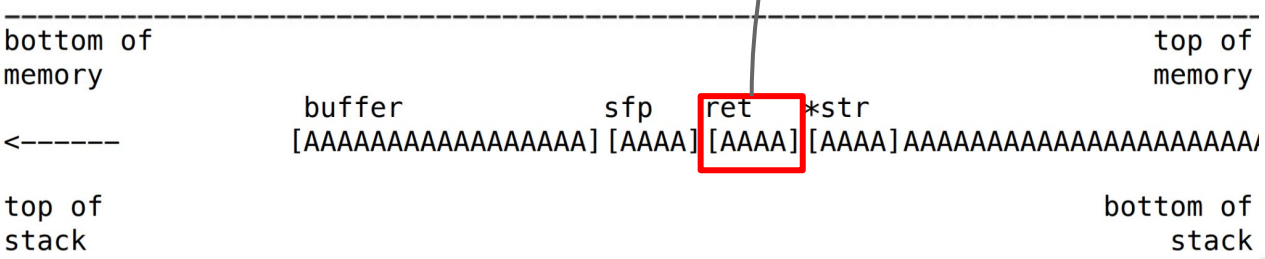

We can control where function returns, i.e., control the execution of the program.

Stack Buffer Overflow

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   char buffer[16];

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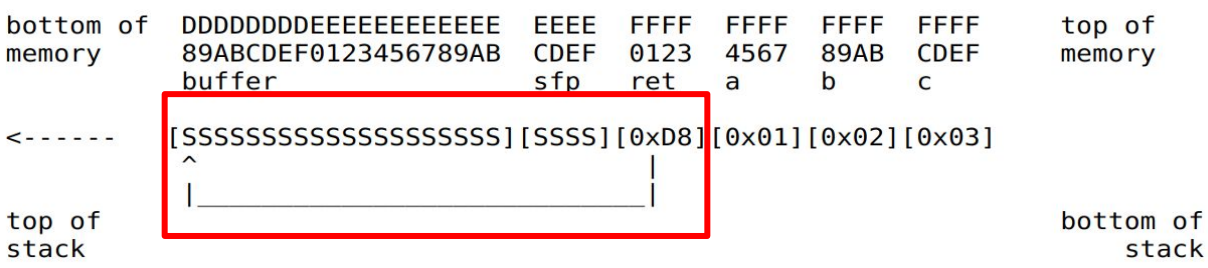
void main() {
  char large_string[256];
  int i;

  for( i = 0; i < 255; i++)
    large_string[i] = 'A';

  function(large_string);
}
-------------------------------------------------------------------------------
```

We can make return address point to the data we just provided (SSSS..), i.e., make the program execute our code.



Integer Overflow

```
int get_two_vars(int sock, char *out, int len){
    char buf1[512], buf2[512];
    unsigned int size1, size2;
    int size;

    if(recv(sock, buf1, sizeof(buf1), 0) < 0){
        return -1;
    }
    if(recv(sock, buf2, sizeof(buf2), 0) < 0){
        return -1;
    }

    /* packet begins with length information */
    memcpy(&size1, buf1, sizeof(int));
    memcpy(&size2, buf2, sizeof(int));

    size = size1 + size2;       /* [1] */

    if(size > len){             /* [2] */
        return -1;
    }

    memcpy(out, buf1, size1);
    memcpy(out + size1, buf2, size2);

    return size;
}
```

Integer Overflow

```
int get_two_vars(int sock, char *out, int len){
    char buf1[512], buf2[512];
    unsigned int size1, size2;
    int size;

    if(recv(sock, buf1, sizeof(buf1), 0) < 0){
        return -1;
    }
    if(recv(sock, buf2, sizeof(buf2), 0) < 0){
        return -1;
    }

    return size;
}
```

Read 2 pieces of data from socket.

Integer Overflow

```
int get_two_vars(int sock, char *out, int len){
    char buf1[512], buf2[512];
    unsigned int size1, size2;
    int size;

    if(recv(sock, buf1, sizeof(buf1), 0) < 0){
        return -1;
    }
    if(recv(sock, buf2, sizeof(buf2), 0) < 0){
        return -1;
    }
    /* packet begins with length information */
    memcpy(&size1, buf1, sizeof(int));
    memcpy(&size2, buf2, sizeof(int));
    return size;
}
```

Convert first 4 bytes into integers.

Integer Overflow

```
int get_two_vars(int sock, char *out, int len){
    char buf1[512], buf2[512];
    unsigned int size1, size2;
    int size;

    if(recv(sock, buf1, sizeof(buf1), 0) < 0){
        return -1;
    }
    if(recv(sock, buf2, sizeof(buf2), 0) < 0){
        return -1;
    }

    /* packet begins with length information */
    memcpy(&size1, buf1, sizeof(int));
    memcpy(&size2, buf2, sizeof(int));

    size = size1 + size2;       /* [1] */

    if(size > len){             /* [2] */
        return -1;
    }

    return size;
}
```

Add both the numbers and check that sum is less than len.

Integer Overflow

```
int get_two_vars(int sock, char *out, int len){
    char buf1[512], buf2[512];
    unsigned int size1, size2;
    int size;

    if(recv(sock, buf1, sizeof(buf1), 0) < 0){
        return -1;
    }
    if(recv(sock, buf2, sizeof(buf2), 0) < 0){
        return -1;
    }

    /* packet begins with length information */
    memcpy(&size1, buf1, sizeof(int));
    memcpy(&size2, buf2, sizeof(int));

    size = size1 + size2;       /* [1] */

    if(size > len){             /* [2] */
        return -1;
    }

    memcpy(out, buf1, size1);
    memcpy(out + size1, buf2, size2);

    return size;
}
```

Copy the data into out buffer.

What's wrong?

```
int get_two_vars(int sock, char *out, int len){
    char buf1[512], buf2[512];
    unsigned int size1, size2;
    int size;

    if(recv(sock, buf1, sizeof(buf1), 0) < 0){
        return -1;
    }
    if(recv(sock, buf2, sizeof(buf2), 0) < 0){
        return -1;
    }

    /* packet begins with length information */
    memcpy(&size1, buf1, sizeof(int));
    memcpy(&size2, buf2, sizeof(int));

    size = size1 + size2;       /* [1] */

    if(size > len){             /* [2] */
        return -1;
    }

    return size;
}
```

Say len = 16

What happens when:
size1 = 0x7fffffff
size2 = 0x7fffffff

What's wrong? Integer Overflow

```
int get_two_vars(int sock, char *out, int len){
    char buf1[512], buf2[512];
    unsigned int size1, size2;
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    if(recv(sock, buf1, sizeof(buf1), 0) < 0){
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    }
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        return -1;
    }

    /* packet begins with length information */
    memcpy(&size1, buf1, sizeof(int));
    memcpy(&size2, buf2, sizeof(int));

    size = size1 + size2;       /* [1] */

    if(size > len){             /* [2] */
        return -1;
    }

    return size;
}
```

Say len = 16

What happens when:
size1 = 0x7fffffff
size2 = 0x7fffffff
size = (0x7fffffff + 0x7fffffff = 0xfffffffe (-2)) and (-2 < 16)

Integer Overflow

```
int get_two_vars(int sock, char *out, int len){
    char buf1[512], buf2[512];
    unsigned int size1, size2;
    int size;

    if(recv(sock, buf1, sizeof(buf1), 0) < 0){
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    }

    memcpy(out, buf1, size1);
    memcpy(out + size1, buf2, size2);

    return size;
}
```

Say len = 16

Overflowing the buffer pointed by out

We are copying 2*0x7fffffff bytes into out whose size is just 16.

Integer Overflow

```
int get_two_vars(int sock, char *out, int len){
    char buf1[512], buf2[512];
    unsigned int size1, size2;
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    if(recv(sock, buf1, sizeof(buf1), 0) < 0){
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    }
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    size = size1 + size2;       /* [1] */

    if(size > len){             /* [2] */
        return -1;
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    memcpy(out, buf1, size1);
    memcpy(out + size1, buf2, size2);

    return size;
}
```

Say len = 16

Overflowing the buffer pointed by out

What if out is on stack? **Stack based buffer-overflow!!**

We are copying 2*0x7fffffff bytes into out whose size is just 16.

Temporal Vulnerabilities

(use-after-free, double free)

Race Condition to Memory Corruption

References

Basics: https://www.youtube.com/watch?v=VroEiMOJPm8

Wargames: https://overthewire.org/wargames/ , https://pwnable.kr/

Temporal vulnerabilities exploitation: https://github.com/shellphish/how2heap