UCSDCSE
Computer Science and Engineering

CSE 127

Week 3 Discussion

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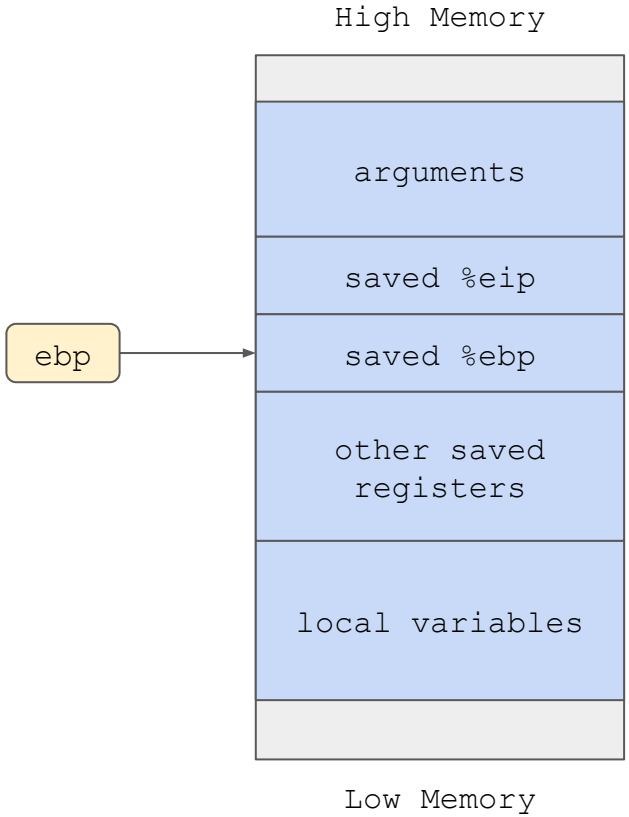
Stack Layout (Revision)



`%eip` is a register pointing to the instruction that CPU will execute in next cycle

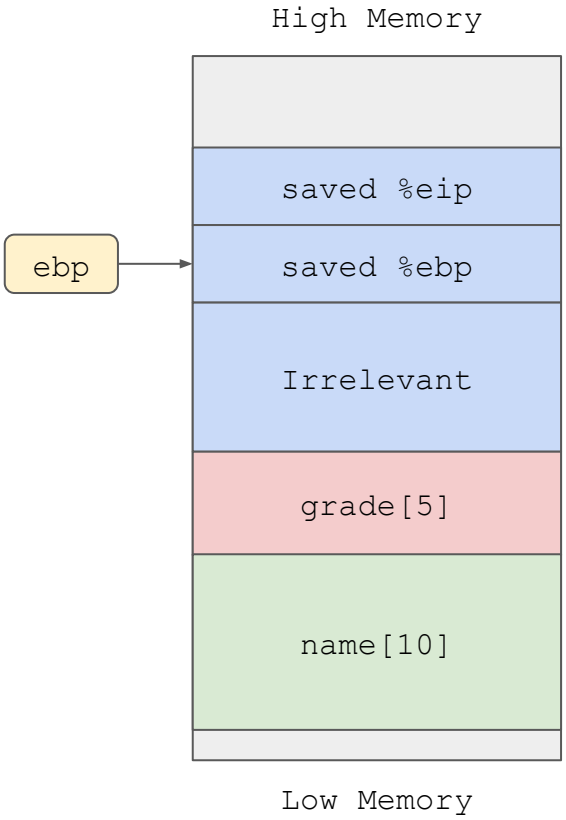
saved `%eip` references to a 4-byte address value stored on stack

saved `%eip` is stored on stack when a function call is made. It has the address of where to resume execution in the caller function

When a function returns, the saved `%eip` value will be popped into the register `%eip` → control will transfer to where saved `%eip` points to

return address == saved return address == saved `%eip` == `%ebp+4`

Target 0

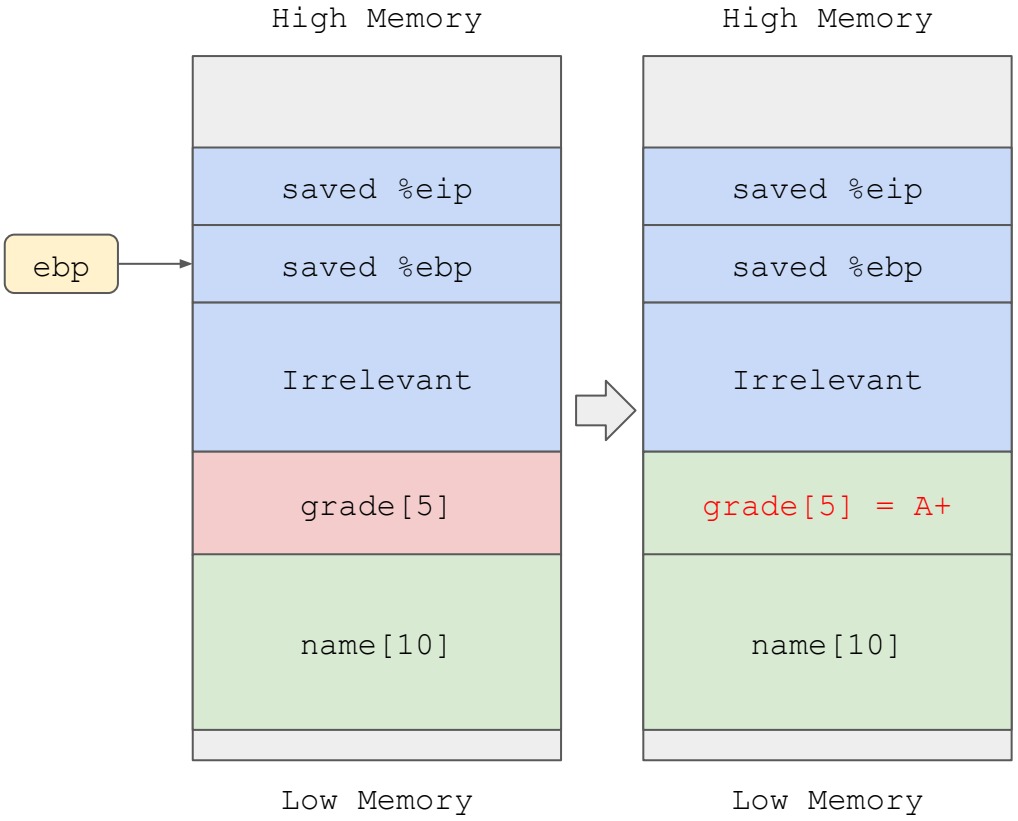


- How does `gets` copy stdin into `name`?
- When does `gets` stop copying?
- Will `gets` check the boundary between `name` and `grade`?

```
int _main(int argc, char *argv[])
{
        char grade[5];
        char name[10];

        strcpy(grade, "nil");

        gets(name);

        printf("Hi %s! Your grade is %s.\n", name,
grade);

        exit(0);
}
```

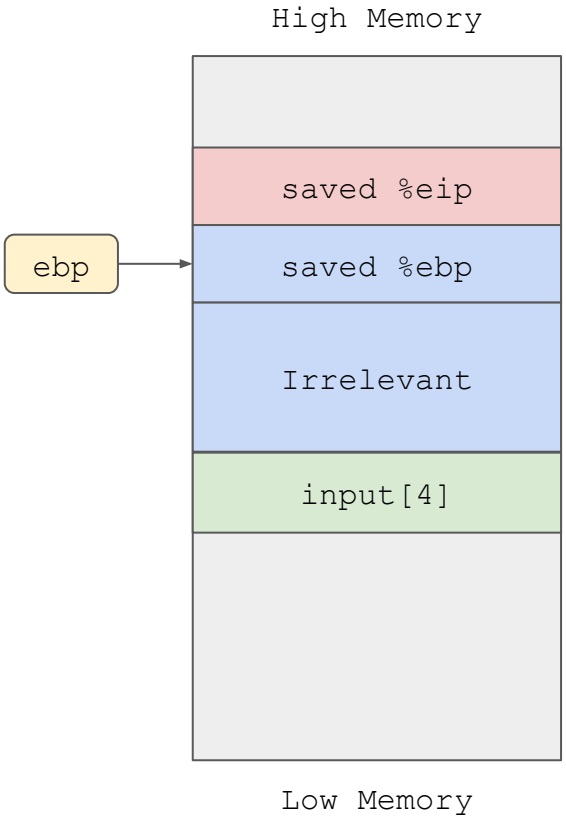
Be careful, when `name` is printed, no extra garbage content should be printed. Think about when `printf` stops prints given a pointer.

Target 0




```
int _main(int argc, char *argv[])
{
        char grade[5];
        char name[10];

        strcpy(grade, "nil");

        gets(name);

        printf("Hi %s! Your grade is %s.\n", name,
grade);

        exit(0);
}
```

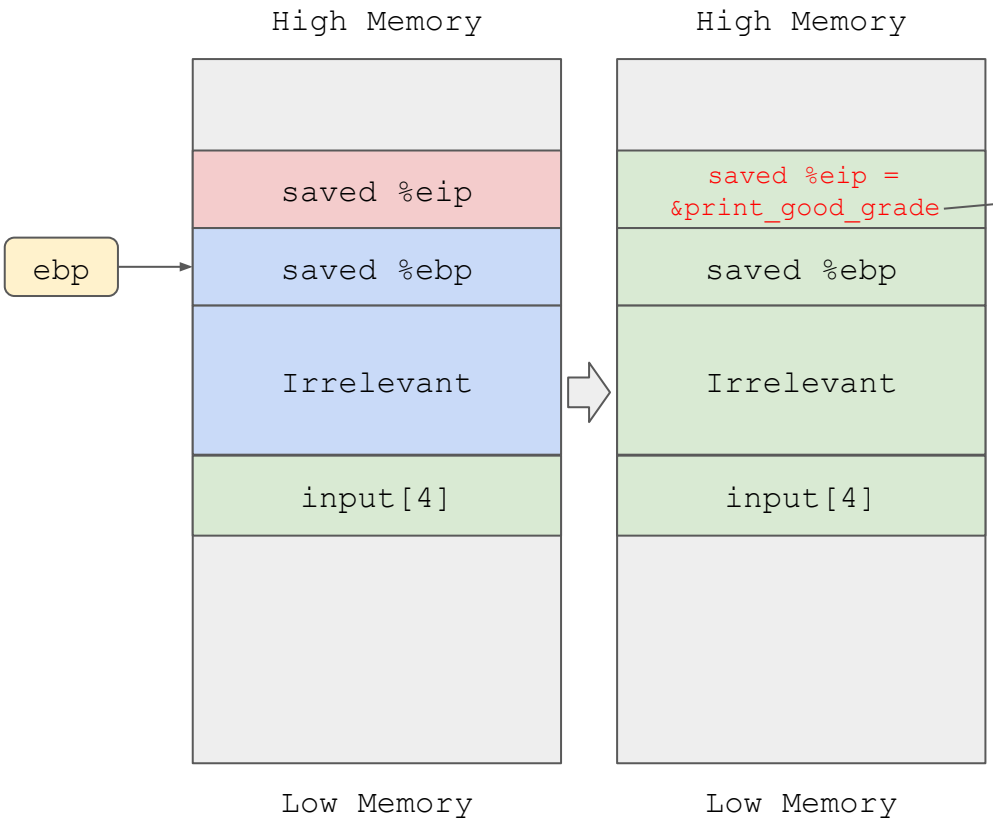
Target 1



- What is the distance between `input` and saved `%eip`?
- How do you fill the gap in between?
- Where do you want to redirect control to?

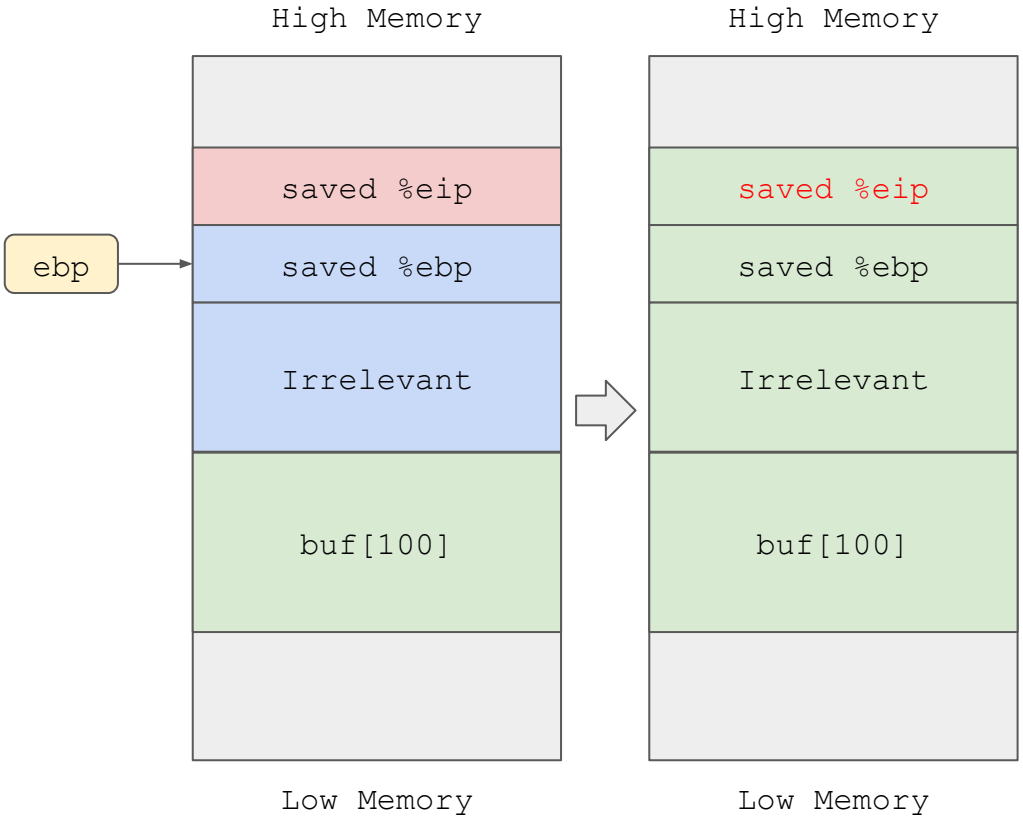
```
void print_bad_grade(void)
{
        puts("Your grade is nil.");
        exit(0);
}

void print_good_grade(void)
{
        puts("Your grade is perfect.");
        exit(1);
}

void vulnerable()
{
        char input[4];
        gets(input);
}

int _main()
{
        vulnerable();
        print_bad_grade();
        return 0;
}
```

Target 1




```
void print_bad_grade(void)
{
        puts("Your grade is nil.");
        exit(0);
}

void print_good_grade(void)
{
        puts("Your grade is perfect.");
        exit(1);
}

void vulnerable()
{
        char input[4];
        gets(input);
}

int _main()
{
        vulnerable();
        print_bad_grade();
        return 0;
}
```

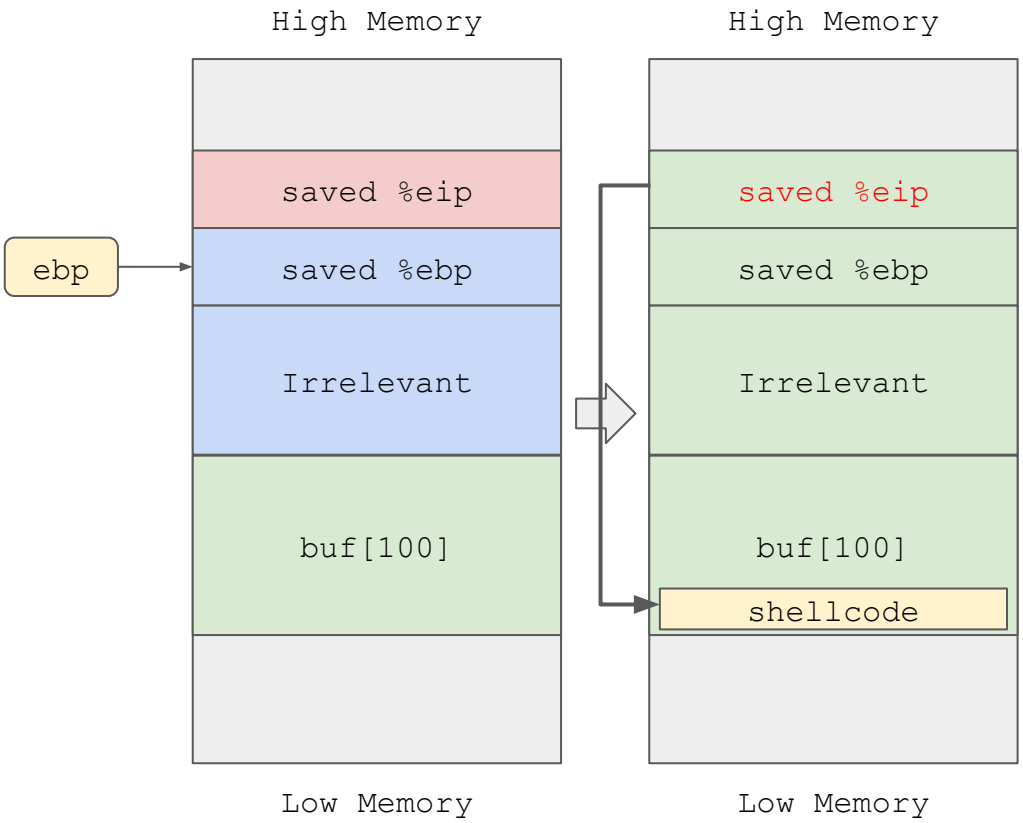
Target 2




```
void vulnerable(char *arg)
{
        char buf[100];
        strcpy(buf, arg);
}

int _main(int argc, char **argv)
{
        if (argc != 2) {
                fprintf(stderr, "Error: need a command-line
argument\n");
                return 1;
        }
        vulnerable(argv[1]);
        return 0;
}
```

Where do you want to transfer control to?

Target 2




```
void vulnerable(char *arg)
{
        char buf[100];
        strcpy(buf, arg);
}

int _main(int argc, char **argv)
{
        if (argc != 2) {
                fprintf(stderr, "Error: need a command-line
argument\n");
                return 1;
        }
        vulnerable(argv[1]);
        return 0;
}
```

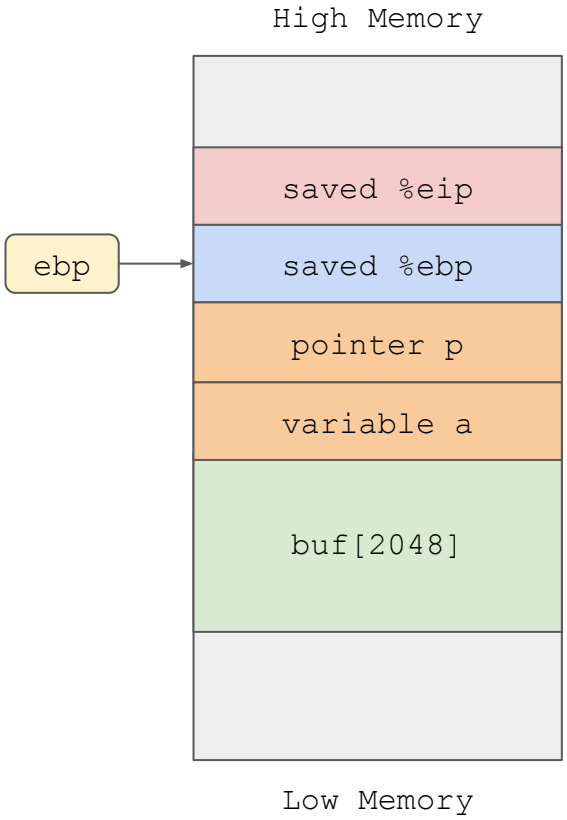
Where do you want to transfer control to?

Shellcode - Simple examples and explanations

- https://www.youtube.com/watch?v=1S0aBV-Waeo

- https://www.youtube.com/watch?v=hJ8IwyhqzD4

Target 3 (Hint)




```
void vulnerable(char *arg)
{
        int *p;
        int a;
        char buf[2048];

        strncpy(buf, arg, sizeof(buf) + 8);

        *p = a;
}
```

- Figure out what goes in ‘p’ and ‘a’
- *p = a is basically dereferencing ‘a’
- Think about how dereferencing can be taken advantage of

Target 4 (Hint)

- count: 32-bit unsigned integer
- What happens when I overflow an unsigned int?

```
int main() {
	unsigned int a = pow(2, 30) + 127;
	unsigned int b = pow(2, 31) + 100;

	printf("%u\n", a * 4);
	printf("%u\n", b * 2);
}
```

```
void read_elements(FILE *f, int *buf, unsigned int count)
{
	unsigned int i;
	for (i=0; i < count; i++) {
		if (fread(&buf[i], sizeof(unsigned int), 1, f) < 1) {
			break;
		}
	}
}

void read_file(char *name)
{
	FILE *f = fopen(name, "rb");
	…..

	unsigned int count;
	fread(&count, sizeof(unsigned int), 1, f);

	unsigned int *buf = alloca(count * sizeof(unsigned int));
	….

	read_elements(f, buf, count);
}
```

Helpful links

- https://devblogs.microsoft.com/oldnewthing/20050107-00/?p=36773
- https://www.acunetix.com/blog/web-security-zone/what-is-integer-overflow/
- https://stackoverflow.com/questions/9193880/overflowing-of-unsigned-int

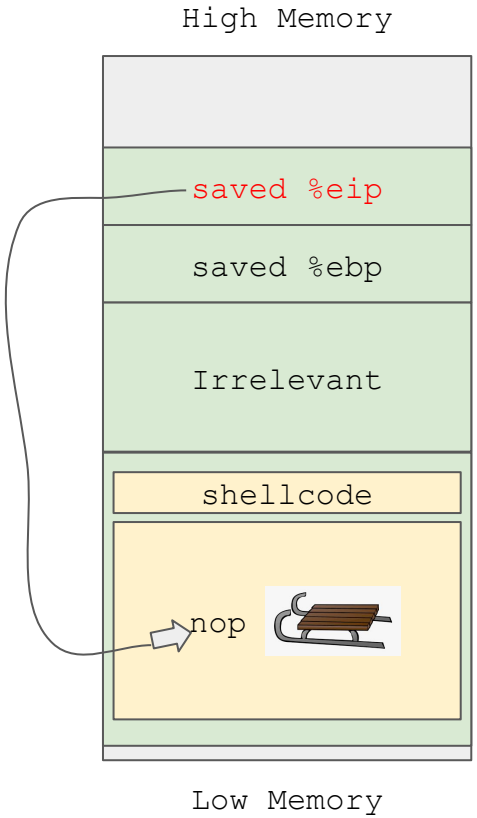
Target 5 (Hint)

- Remember - Compiled with DEP enabled
- **W^X (Write XOR eXecute)!**
- You cannot put shellcode in buffer and point to it from return address.
- What can you do?
- **"Return-to-libc" style of attack**
- What does **system("/bin/sh");** do?
- Review lecture 6, detailed walkthrough

```
// Compiled with DEP enabled.

void greetings(void)
{
        system("echo Hello World");
}

void vulnerable(char *arg)
{
        char buf[10];
        strcpy(buf, arg);
}

int _main(int argc, char *argv[])
{
        ….
        setuid(0);
        vulnerable(argv[1]);
        greetings();
        ….
}
```

Target 6 (Hint)

- ASLR (address-space layout randomization) enabled
- Stack can be placed anywhere in memory (0−255 bytes)
- How can I make sure my shell code always hit?
- Hint: NOP sleds
- NOP = 0X90
- Make sure you can open a root shell 100% of the time




```
// Compiled with -DMINIASLR.

void vulnerable(char *arg)
{
        char buf[1024];
        strcpy(buf, arg);
}


int _main(int argc, char *argv[])
{
        ....

        vulnerable(argv[1]);

        return 0;
}
```

Target 7

- Return Oriented Programming
- Extra credit (15 points)

- Identical to target2, but it is compiled with DEP enabled

- Implement a ROP-based attack to bypass DEP and open a root shell.

- **ROPgadget.**
- The --binary, --badbytes, --multibr, and --ropchain flags will be particularly helpful.

- Closest to real-world attacks

```
void vulnerable(char *arg)
{
        char buf[100];
        strcpy(buf, arg);
}

int _main(int argc, char **argv)
{
        if (argc != 2) {
                fprintf(stderr, "Error: need a command-line
argument\n");
                return 1;
        }
        vulnerable(argv[1]);
        return 0;
}
```

```
setuid(0);                  //eax = 23
execve("/bin/sh", 0, 0);    //eax = 11
```