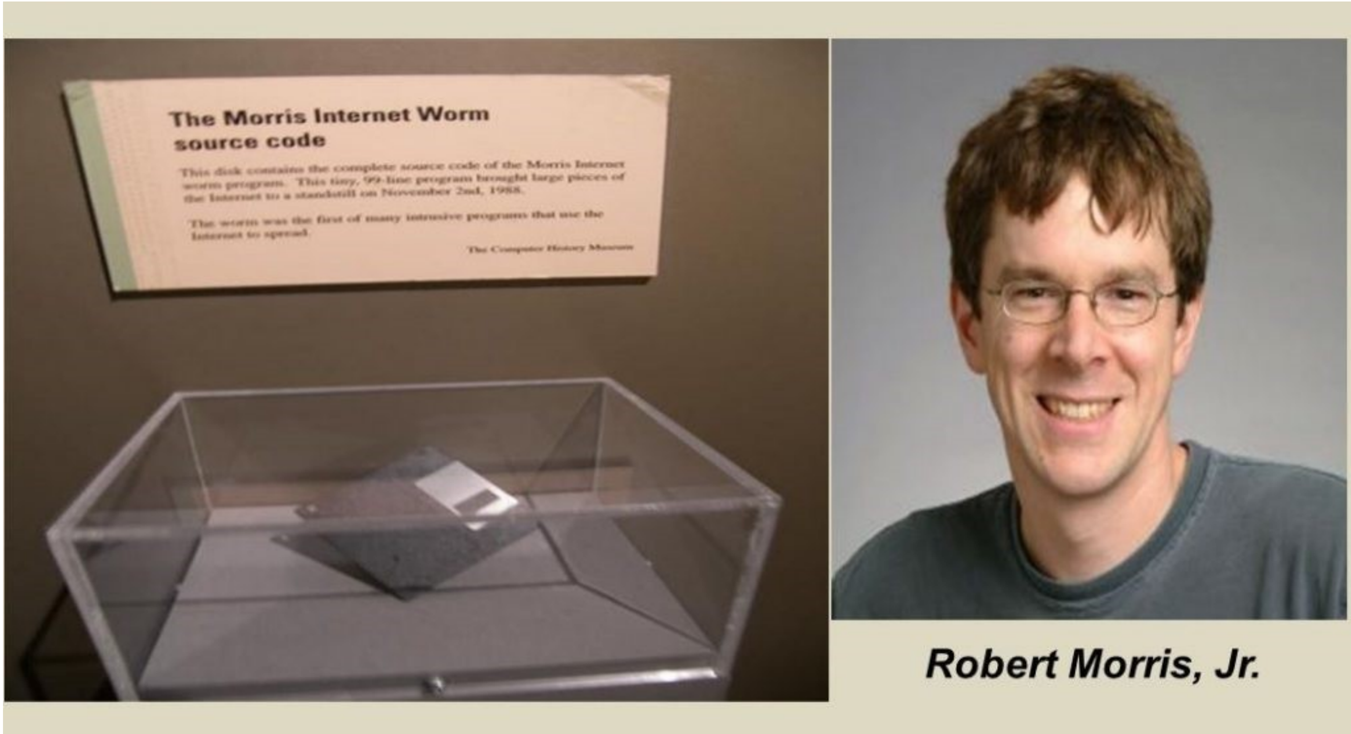
The Morris Internet Worm
source code
This disk contains the complete source code of the Morris Internet worm program. This tiny, 99-line program brought large pieces of the Internet to a standstill on November 2nd, 1988.
The worm was the first of many intrusive programs that use the Internet to spread.
The Computer History Museum
Robert Morris, Jr.

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Overview Over Attack Vectors And Countermeasures For Buffer Overflows

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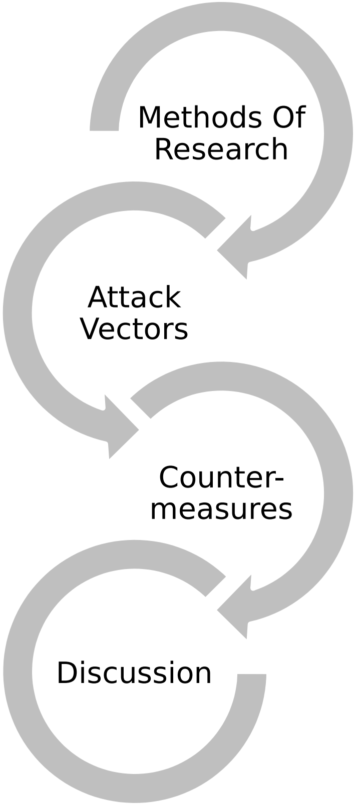
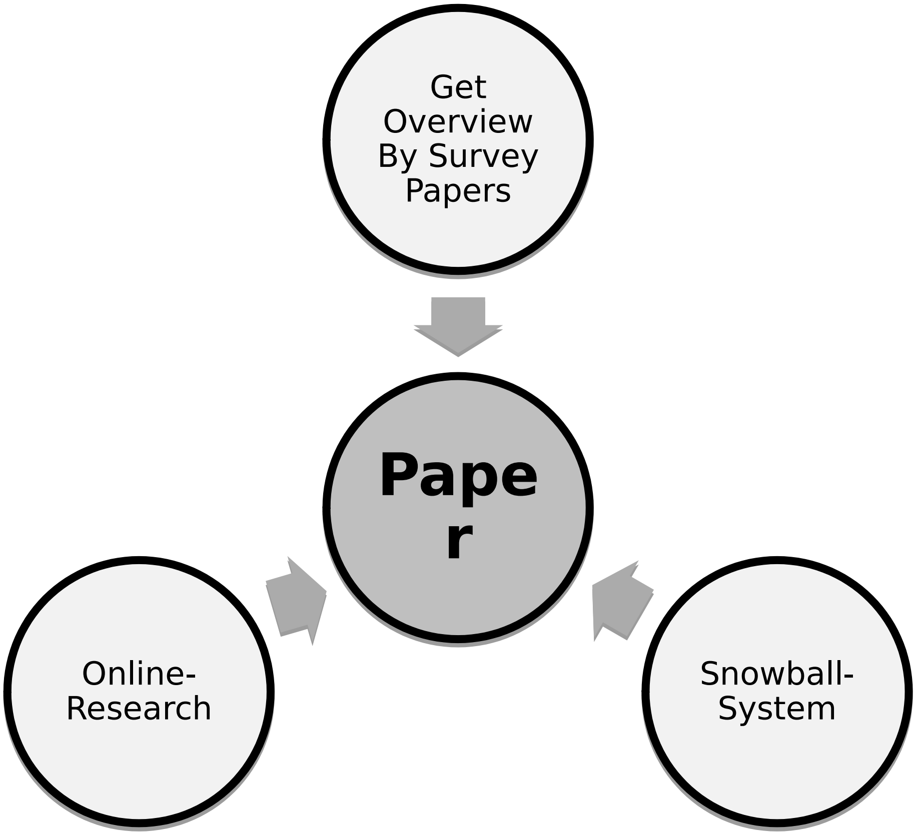
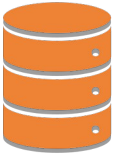
Agenda


Methods Of Research
Attack Vectors
Counter-measures
Discussion

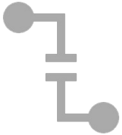
Methods Of Research



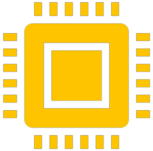
Attack Vectors



Stack-based buffer overflows



Heap-based buffer overflows

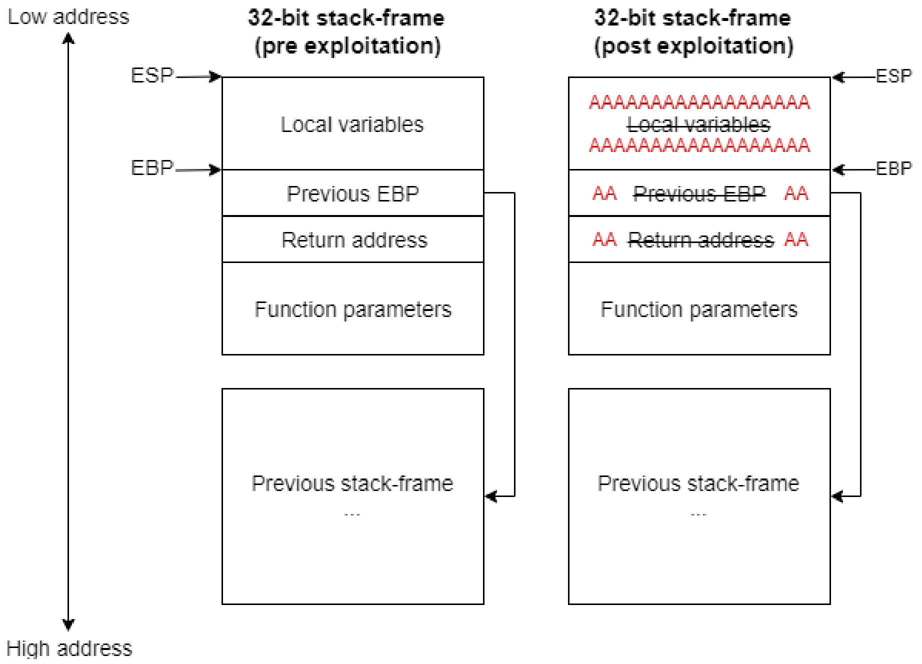


Integer overflows

Stack-based buffer overflows

- Stack contains: Parameters, Local Variables, Return Address, …
- Return Address: Next address to execute when called function returns
- Local Variables: Can contain function pointers
- **General Goal:** Overwriting *Return Address* or *Local Function Pointers* to gain <u>Code Execution</u>

Stack-based buffer overflows



Heap-based buffer overflows

- Heap contains: Class Instances, Function Pointers, Heap Metadata, …
- Heap Metadata: Used by Heap Management operations such as *freeing*, *merging*, *splitting* chunks
- Type confusion: Modify internal Object Type stored by dynamic typing languages such as Python or JavaScript
- **General Goal:** Overwriting *Function Pointers* or *Heap Metadata* to gain Code Execution

Integer overflows

- Does not directly lead to Code Execution

- Used to trigger Heap-based BOFs (buffer overflows)
  → Overflow integer which determines allocation size
  → Integer is smaller than needed size
  ➔ Out of bounds access

- **General Goal:** Triggering a Heap-based BOF to gain Code Execution

ASLR

- Randomize location of program in memory
- Attacker doesn‘t know where payload is located
- Prevents code execution
- Information leak allows exploitation
- Brute-force of 32 bit addresses possible
- Does not prevent DoS
- Compile-time mitigation, no code changes needed

ASLR

```c
#include<stdio.h>

void some_function() {
  puts("Hello, world!\n");
}

int main() {
  void (*function)() = &some_function;
  printf("some_function is located at %p\n", function);
  return 0;
}
```

```
~/wis
➜ gcc example.c -o example

~/wis
➜ ./example
some_function is located at 0x55a96720b149

~/wis
➜ ./example
some_function is located at 0x555f0c1ff149
```

```
~/wis
➜ gcc example.c -o example -no-pie

~/wis
➜ ./example
some_function is located at 0x401136

~/wis
➜ ./example
some_function is located at 0x401136
```

NX

- Memory can be either writable or executable
- Attacker cannot supply shellcode directly
- Code reuse still possible
- Compile-time mitigation, no code changes needed

Stack Canary

- Markers at the end of a stack frame
- Invalid marker → Buffer overflow occurred
- No code changes required
- Only mitigates stack-based BOF
- Knowledge of canary allows bypassing

RAD

- Read-only stack for return addresses
- Compared before return
- Compiler extension
- Only against stack-based BOF

- Each indexing operation is checked
- 100% effective (where applied)
- Non-trivial runtime overhead
- Used in languages with runtimes (Java, C#, Python, ...)

Dependent Types

- Value (size) is associated with a buffer
- Only allow indexing with validated values
- Language extension
- Lot of work to use, but type inference helps

Discussion – Static Methods

+

Wrong Positives

-

Know-How

Costs

Access To Source-Code

Discussion – Static Methods

+

- Wrong Positives

-

- Know-How
- Costs
- Access To Source-Code

Discussion – Static Methods

+

- Wrong Positives

-

- Know-How
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Discussion – Static Methods

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- Know-How
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Discussion – Static Methods

+

- Wrong Positives

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- Know-How
- Costs
- Access To Source-Code

Discussion – Dynamic Methods

+

- Implement-ation

-

- Wrong Positives
- Access To Source Code
- Legacy Code
- Size Of Memory

Discussion – Dynamic Methods

+

- Implement-ation

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- Wrong Positives
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Discussion – Dynamic Methods

+

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- Wrong Positives
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Ref.: [1], [8], [9], [10], [11]

Discussion – Dynamic Methods

+

- Implement-ation

-

- Wrong Positives
- Access To Source Code
- Legacy Code
- Size Of Memory

Ref.: [1], [8], [9], [10], [11]

Discussion - Conclusion

- Until today, a lot of software is developed in unprotected languages

- Combination if techniques provides best results
  - Computational intelligence combined with static methods

Forecast

- More computational intelligence techniques
- Techniques to handle buffer overflow vulnerabilities automatically

Ref.: [1], [8], [9], [10], [11]

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