Code Obfuscation

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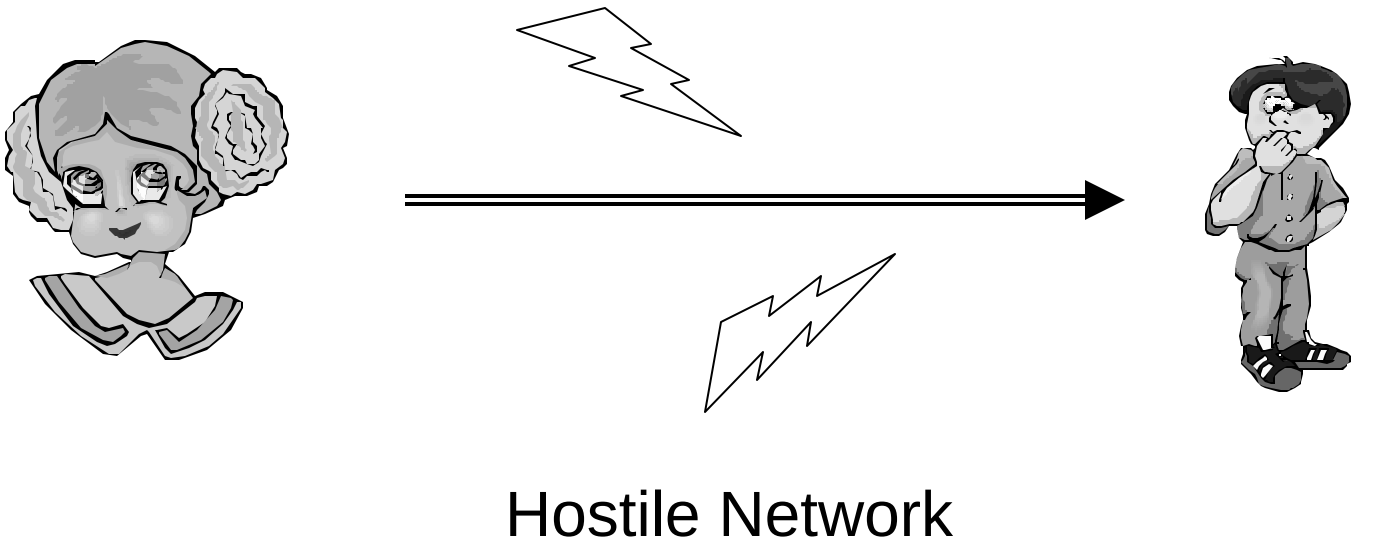
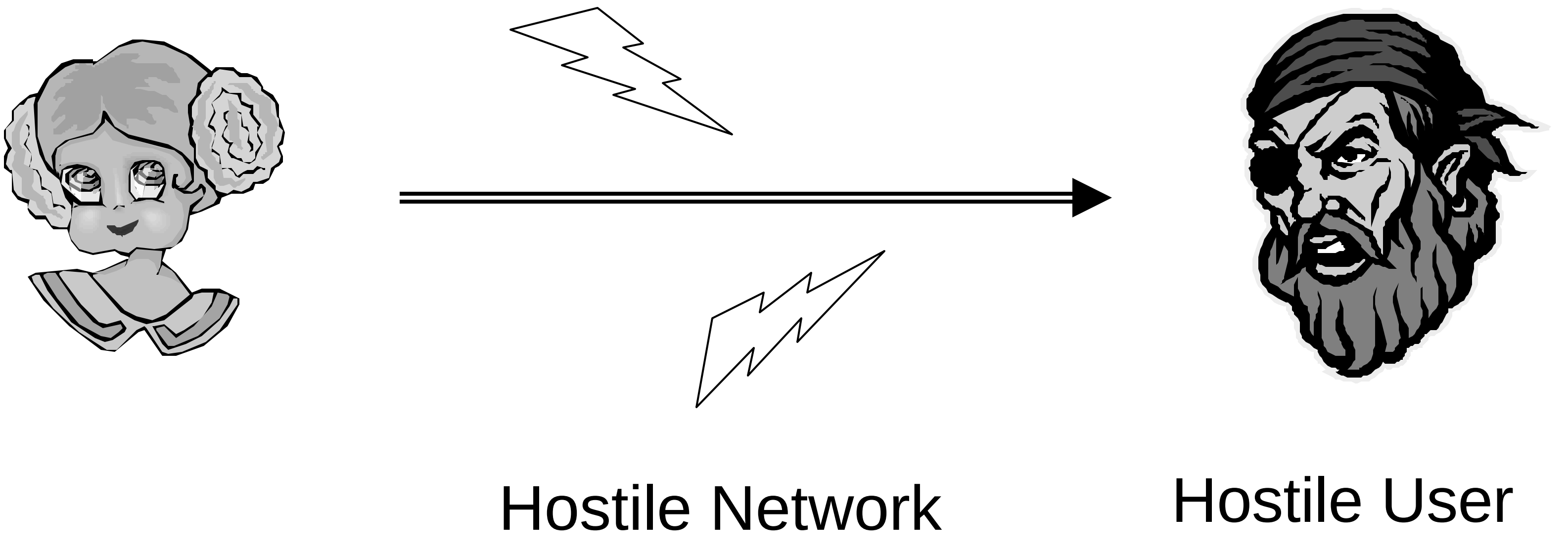
Agenda

- Malicious Host Problem
- Code Obfuscation
- Watermarking and Tamper Proofing
- Market solutions

Traditional Network Security Problem



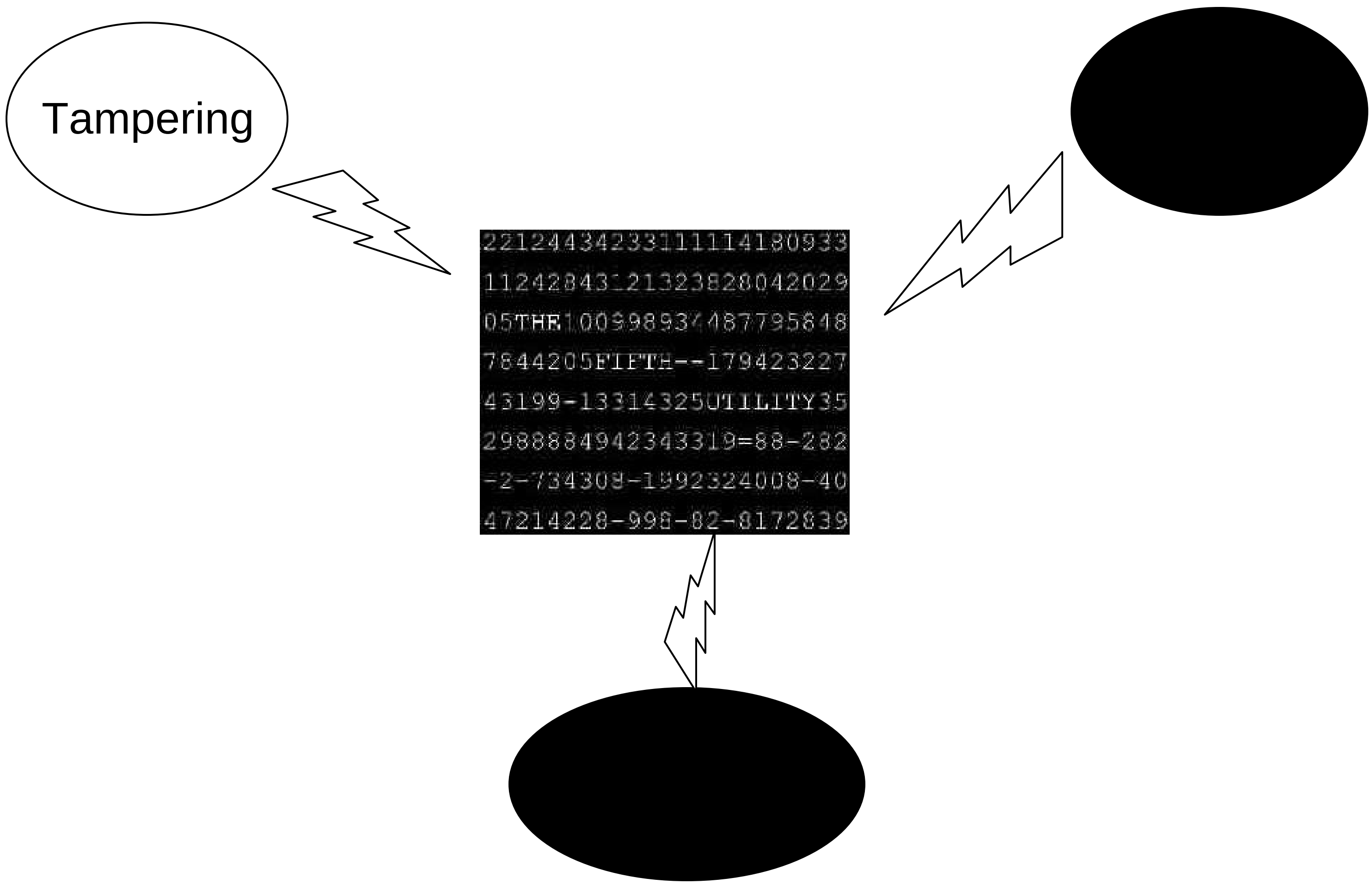
Malicious Host



Motivation

- Intellectual Property Protection
  - Under threat in various forms
    - Reverse engineering
    - Tampering
    - Software Piracy
  - Loss of revenue and finally an overall loss

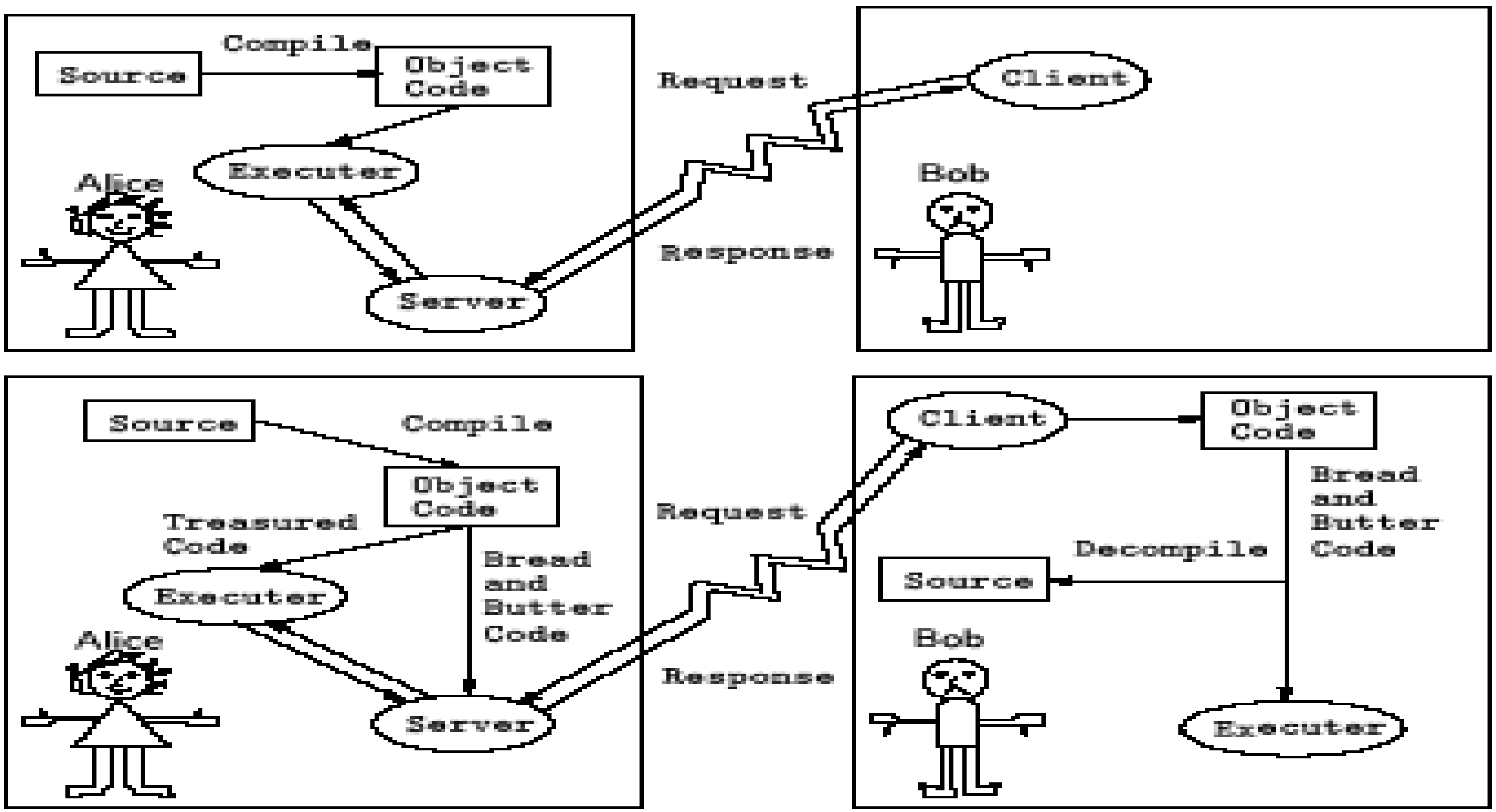
Code under Attack



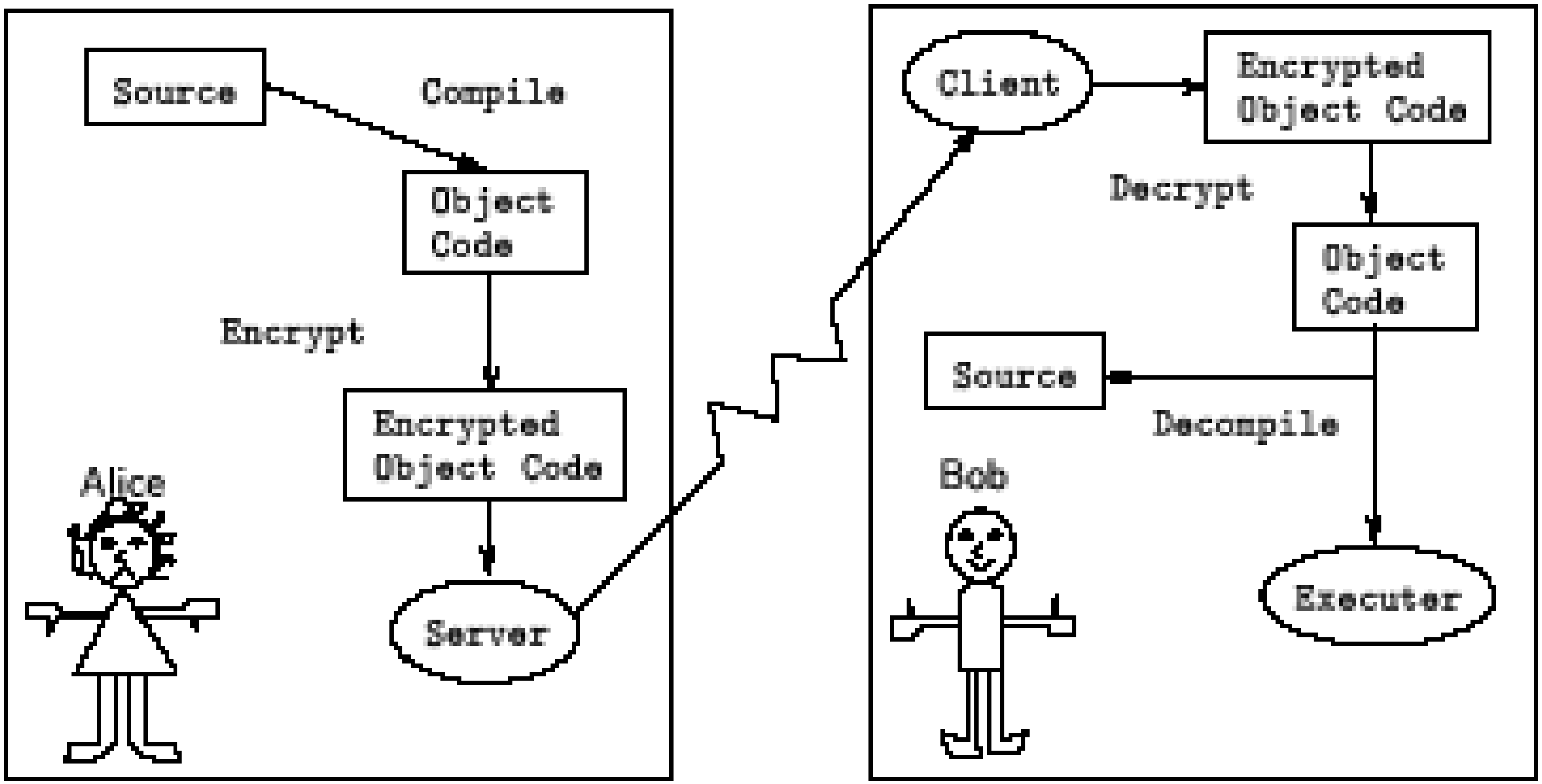
Protection

- Legal battles
  - No Electronic Theft (NET)
  - Digital Millennium Copyright Act (DMCA)
- Technical Protection
  - Server-Side Protection
  - Encryption
  - Native Code
  - Obfuscation

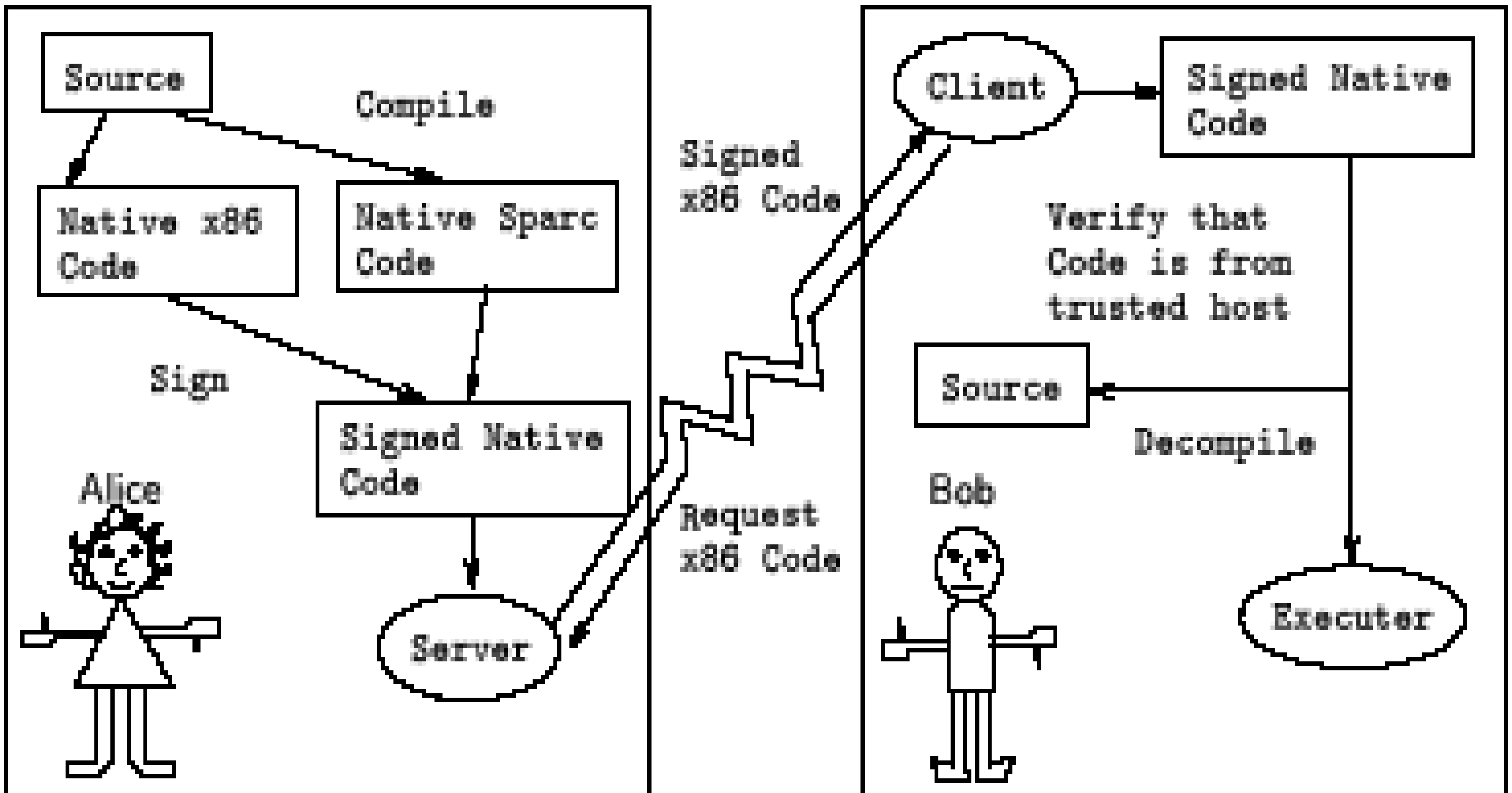
Server-Side Protection



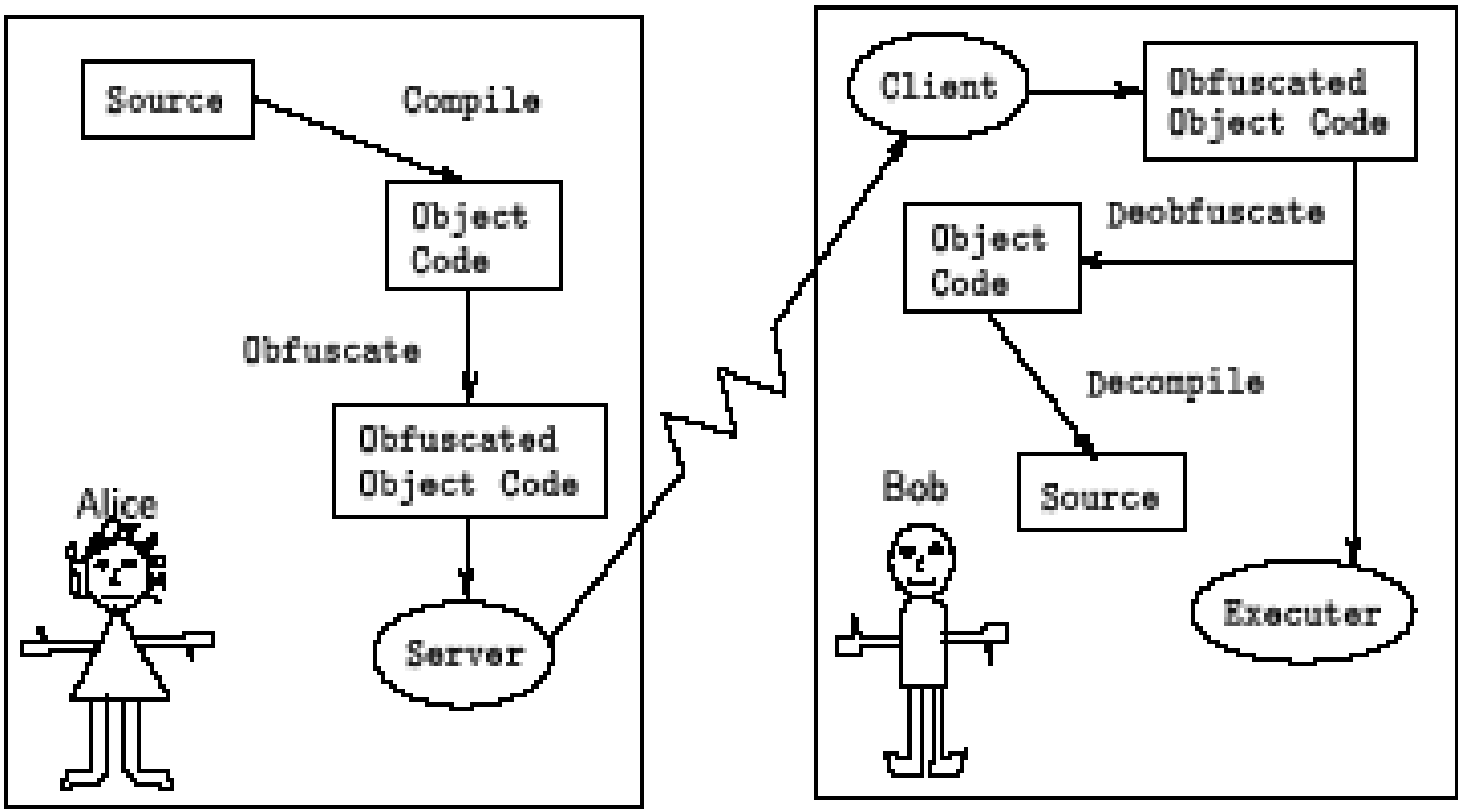
Encryption


Source
Compile
Object Code
Encrypt
Encrypted Object Code
Alice
Server
Client
Encrypted Object Code
Decrypt
Object Code
Source
Decompile
Bob
Executer

Native Code


Source
Compile
Native x86 Code
Native Sparc Code
Sign
Signed Native Code
Alice
Server
Signed x86 Code
Request x86 Code
Client
Signed Native Code
Verify that Code is from trusted host
Source
Decompile
Bob
Executer

Obfuscation



Definition

$P \xrightarrow{T} P'$ is an obfuscating transformation if

- If P fails to terminate or terminates with error, then P’ may or may not terminate
- Otherwise, P’ must terminate and produce same output as P

Measuring Obfuscation

Obfuscation can be measured as sum of the following:

- **Potency** **(E(P')/E(P) – 1)**
- **Resilience** **(trivial, weak, strong, full, 1-way)**
- **Cost** **(free, cheap, costly, dear)**
- **Stealth**

Forget about good software engineering principles

Software metrics

Complexity of software increases:

- Program length
  - No. of operators and operands.
- Data flow complexity
  - Number of inter-block variable references.
- Cyclomatic complexity
  - Number of predicates in a function.
- Nesting complexity
  - Number of nesting level of conditionals in a program.

Software metrics...

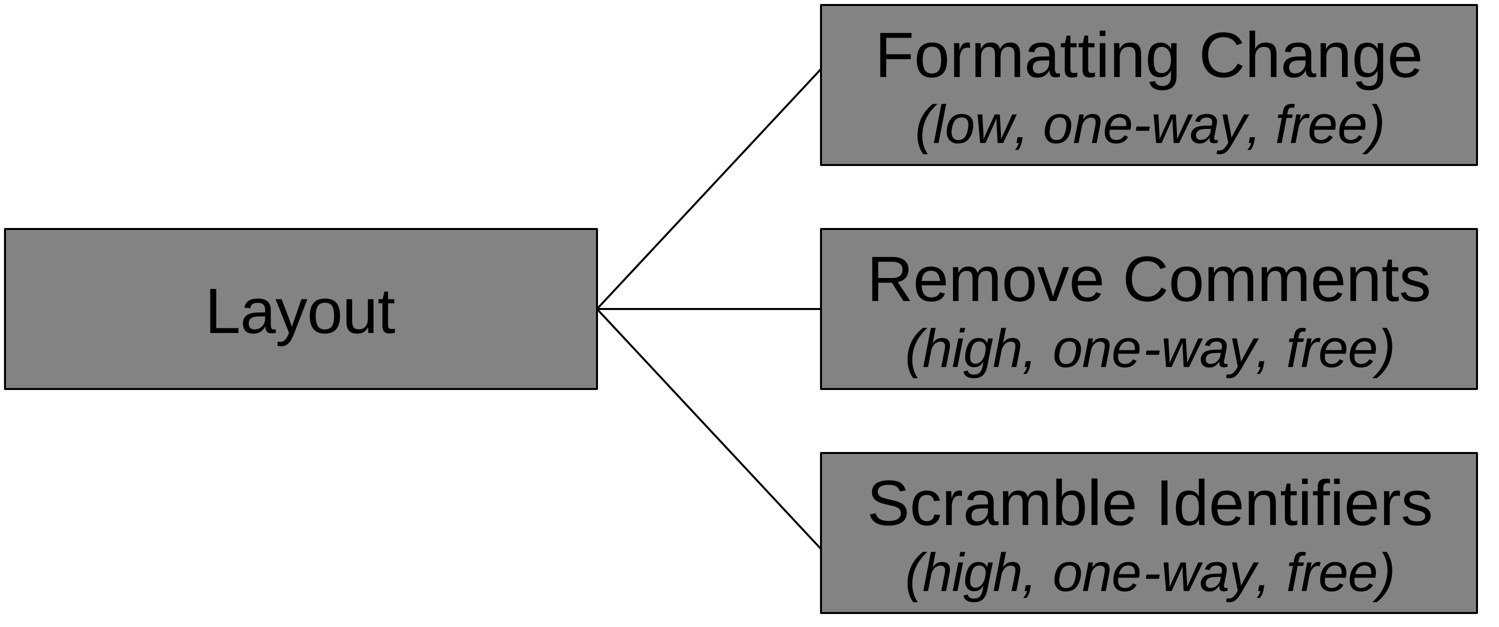
- Data structure complexity
  - Complexity of the static data structures in the program like variables, vectors, records.
- OO Metrics
  - Level of inheritance
  - Coupling
  - Number of methods triggered by another method
  - Non-cohesiveness

Obfuscation Categories

- Layout Obfuscation
- Data Obfuscation
- Control Obfuscation
- Preventive Obfuscation

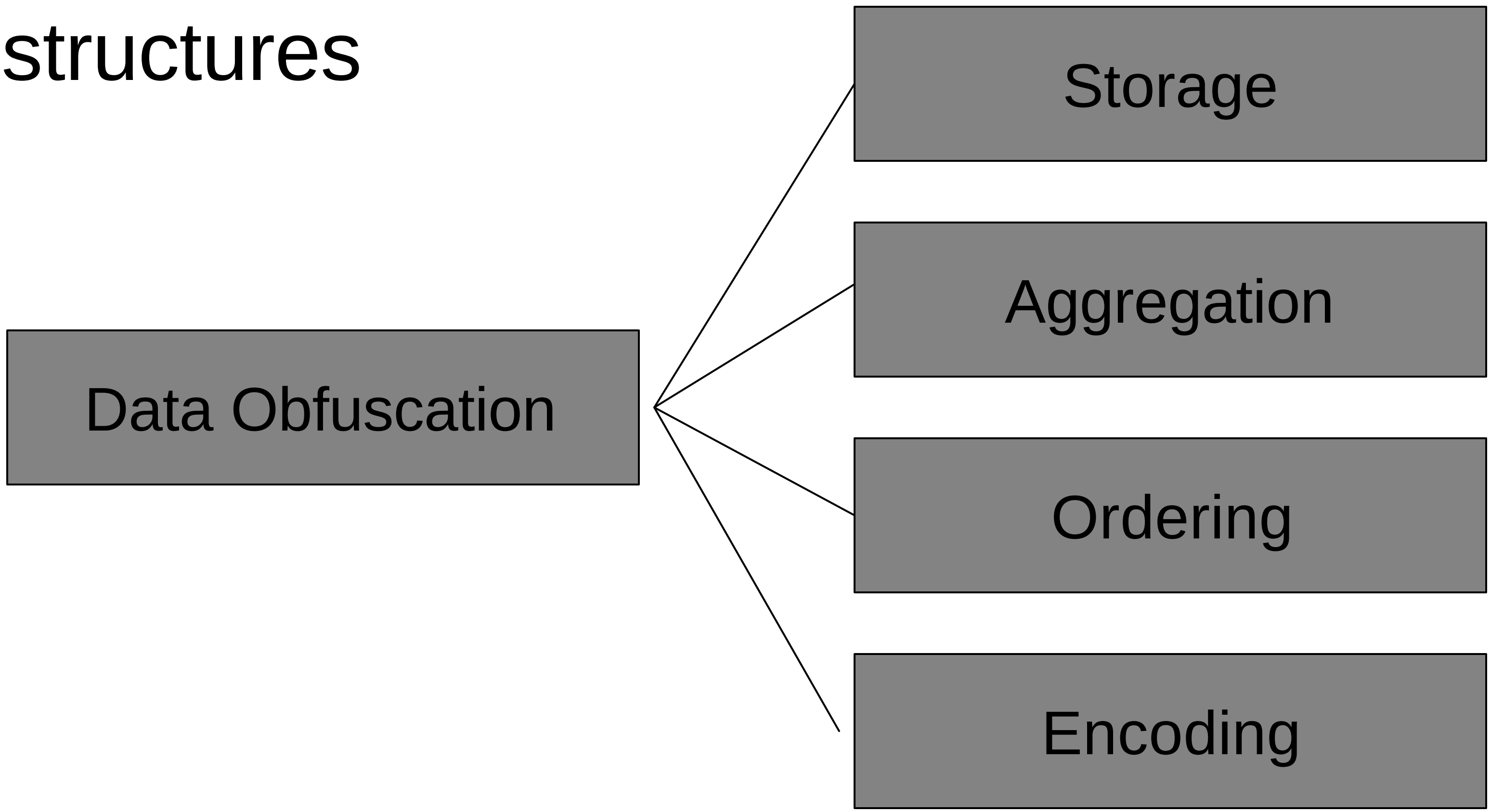
Layout Obfuscation

- Aimed at making the code unreadable



Data Obfuscation

- Aimed at obscuring data and data structures



Storage & Encoding - 1

- Split variables
  - Transform single variable : v = [(v1, v2.. vk)]
  - Increases Potency
  - Required to provide extra functions for variable mapping (higher cost)

Original	Obfuscated
Bool a, b, c	Short a1, a2, a3, b1, b2, c1, c2
a = true, b = false, c = true	a1 = a2=a3 = true, ……..
c = a & b	c1 = ((a1 ^ a2) ^ a3) & (b1 ^ b2) c2 = c1

Storage and Encoding- 2

- Convert Static into Procedural
  - Lots of information conveyed through static variables
  - Convert into function call
  - High potency and resilience (depends on function)

Actual	Obfuscated
String t = “Net”	String retStr(int i) { string s; s[1] = “N”; s[2] = “e”; s[3] = “t”;}

Storage and Encoding- 3

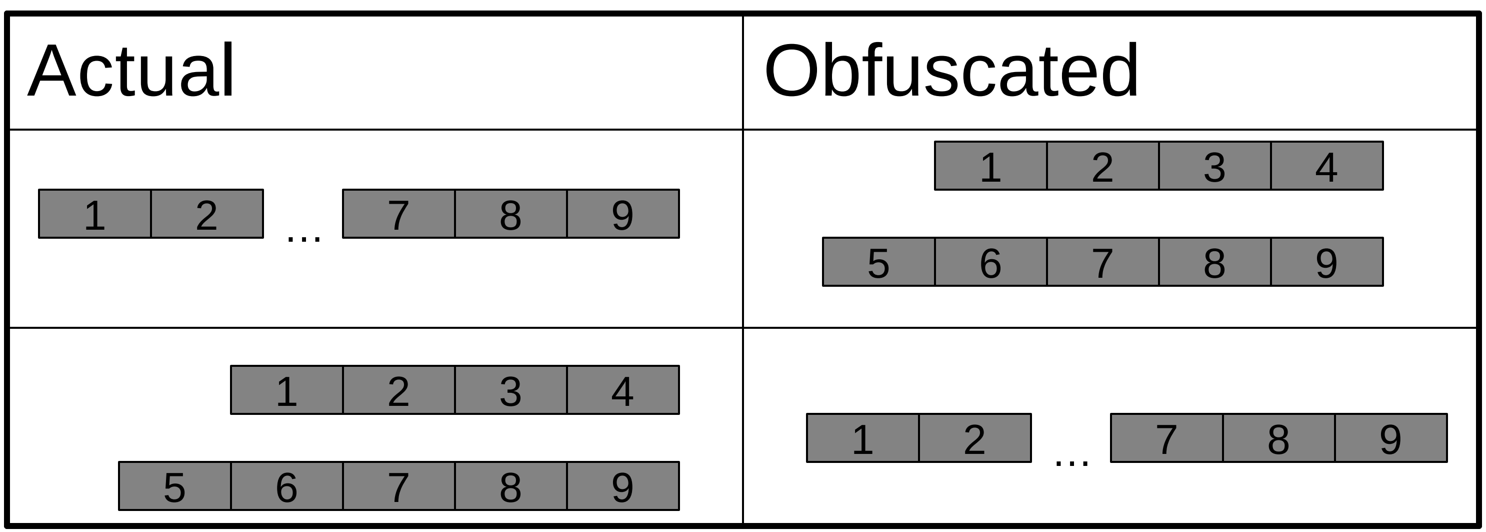
- Other important methods are
  - Scalers to Objects
  - Changing encoding
  - Changing Variable Lifetimes….

Aggregation & Reordering - 1

- Array Transformation
- Modifying Inheritance
- Merging scalar variables
- Reordering execution sequence

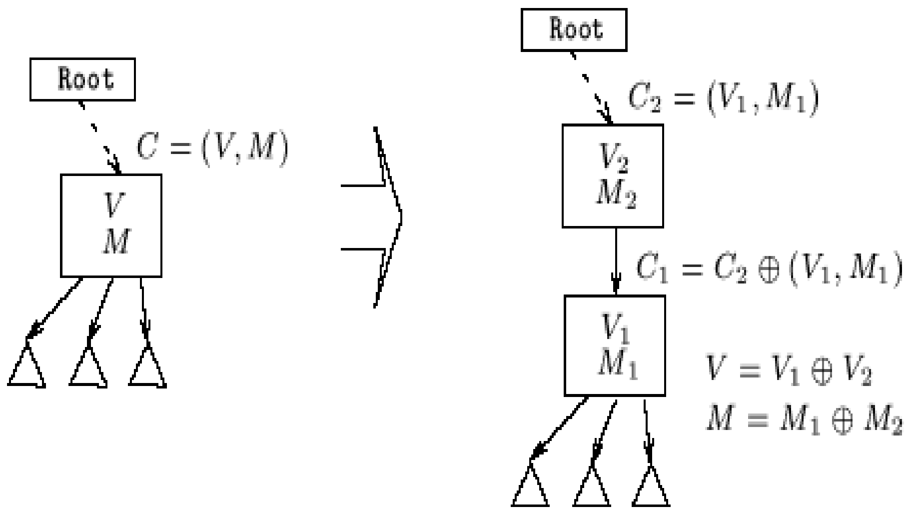
Aggregation & Reordering - 2

- Array Transformation
  - Splitting & folding (increases potency)
  - Merging & flattening (decreases potency)



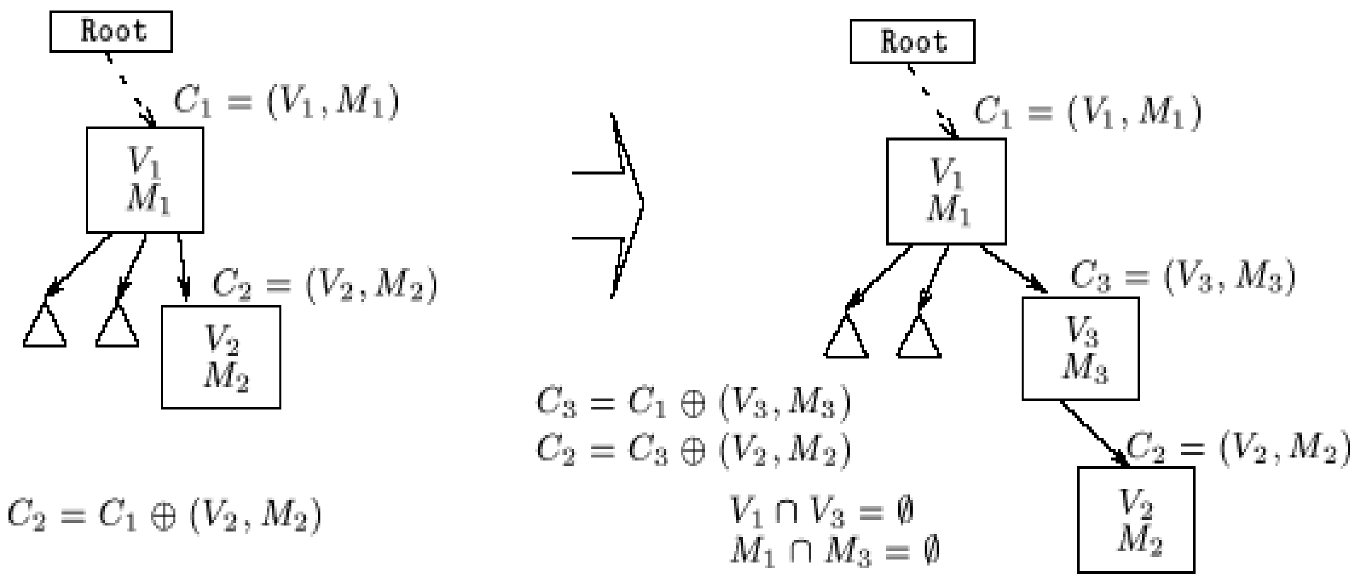
Aggregation & Reordering - 3

- Inheritance
  - Split a class



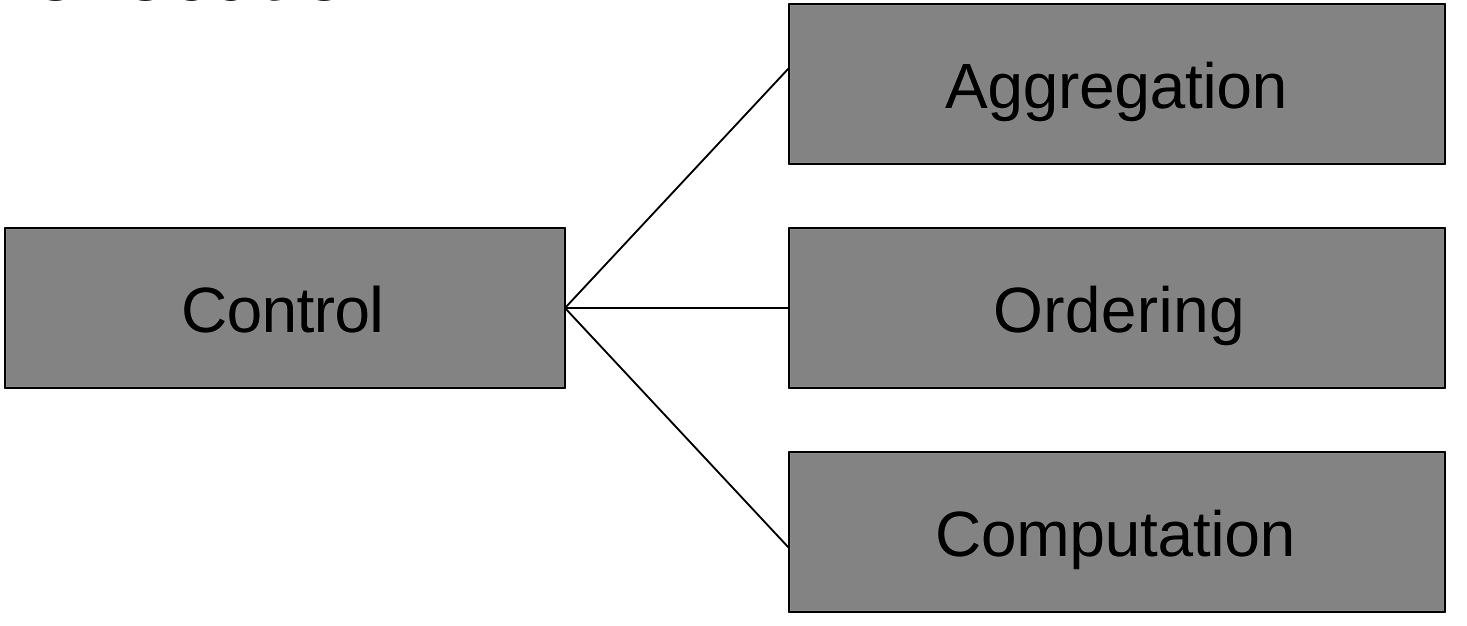
Aggregation & Reordering - 4

- Inheritance
  - Insert a class



Control Obfuscation

- Aimed at obfuscating the flow of execution



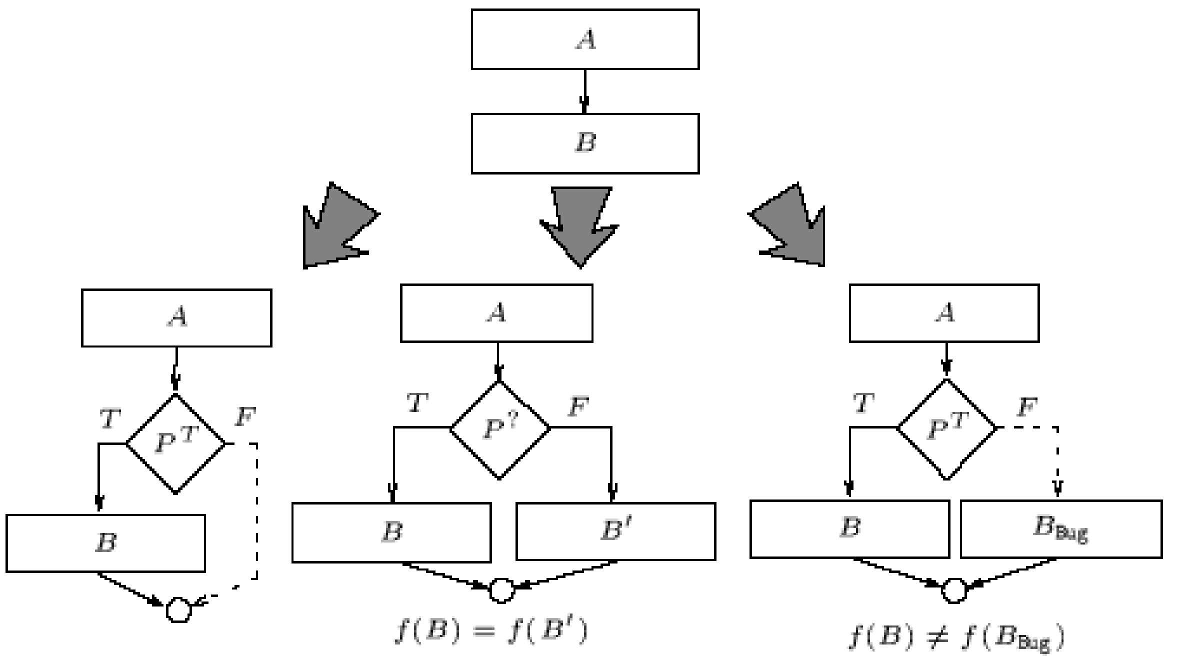
Opaque Construct

- Obfuscator knows the outcome but very hard for de-obfuscator to predict.
- Makes it resilient
- Makes it costly – adding additional code.

```
{
        int v, a= 5, b= 6;
        v=11 = a + b;
        if ( b > 5 ) T……
        if ( random ( 1, 5) < 0 )F ….
}
```

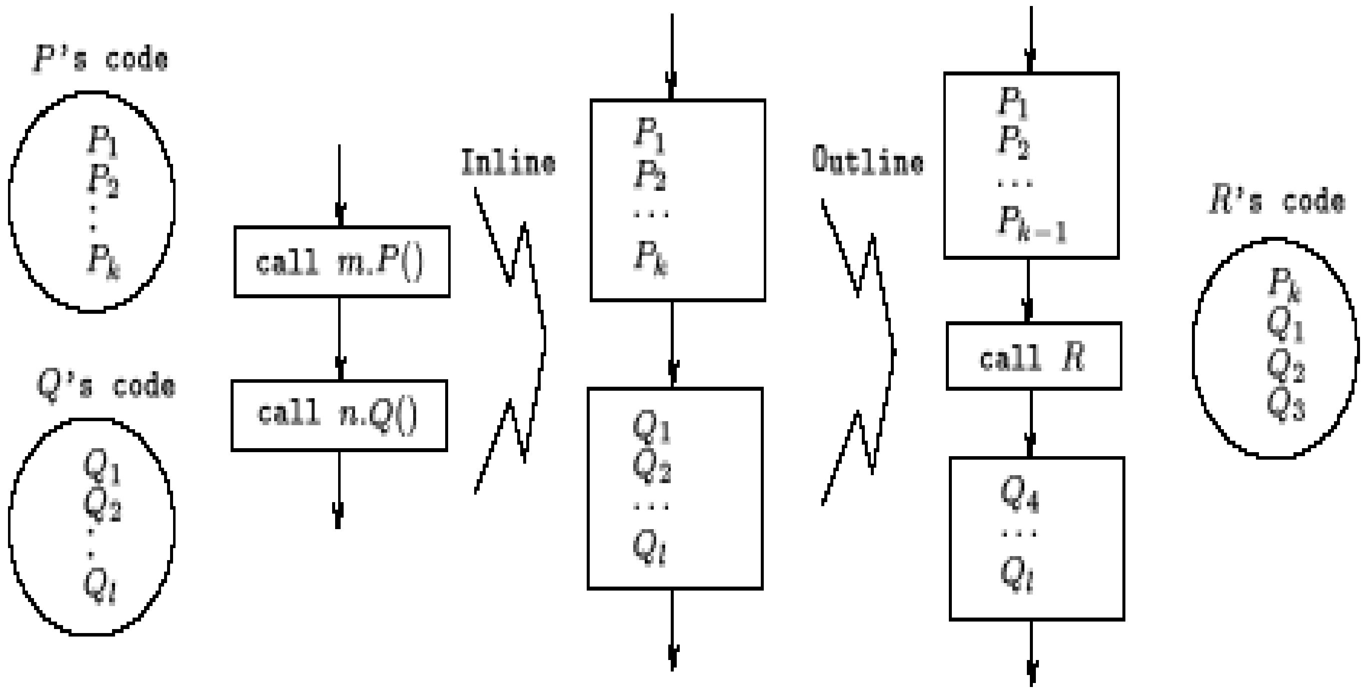
Redundant Code

- Introducing opaque predicates
- Introducing multiple obfuscated loops
- Introducing buggy loops



Inline and Outline

- Inline: removes procedural abstraction.
- Outline: creates bogus procedural abstraction.
- High resilience

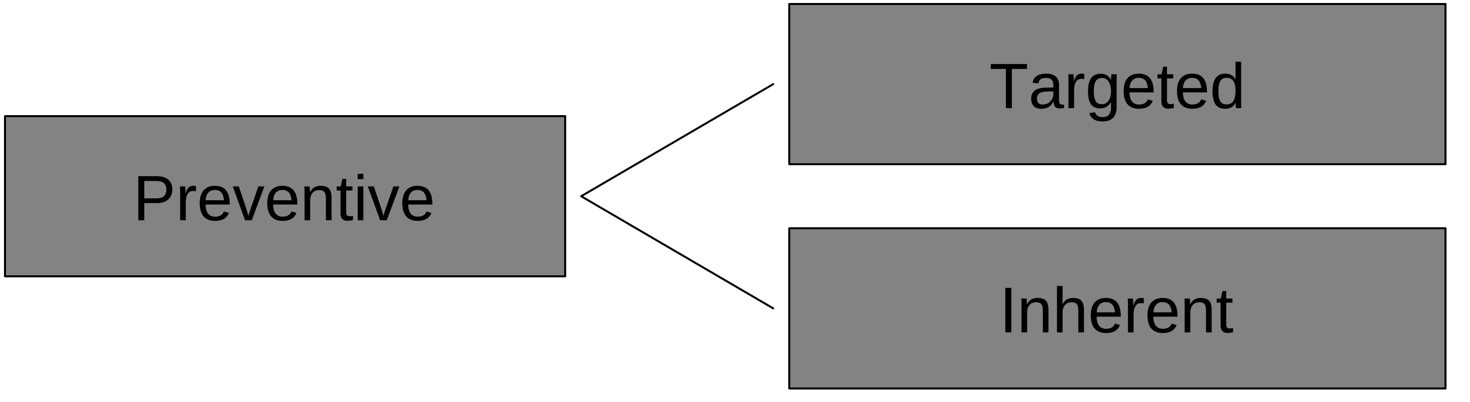


Other Control Obfuscation methods

- Cloning
- Interleaving Methods
- Non-reducible Flow Graphs

Preventive Obfuscation

- Works by trying to break the known de-obfuscation techniques.



Inherent

- In the example
  - Added bogus data
  - Prevented de-obfuscator from automatic analysis

Actual Code	Obfuscated Code
For (i = 1; i<= 10; i++) A[i] = I;	Int B[50] For (i=10; i>= 1; i--) { A[i] = I; B[i] += B[i*i/2];}

Target

- It targets specific de-obfuscating programs
- E.g. HoseMocha example
  - Crashes if we add any code after return statement

Why don’t we use obfuscation

- Cost of obfuscation
  - Execution time
  - High program complexity
  - Effort
  - More $$$
- Ignorance

Solutions to Malicious Host

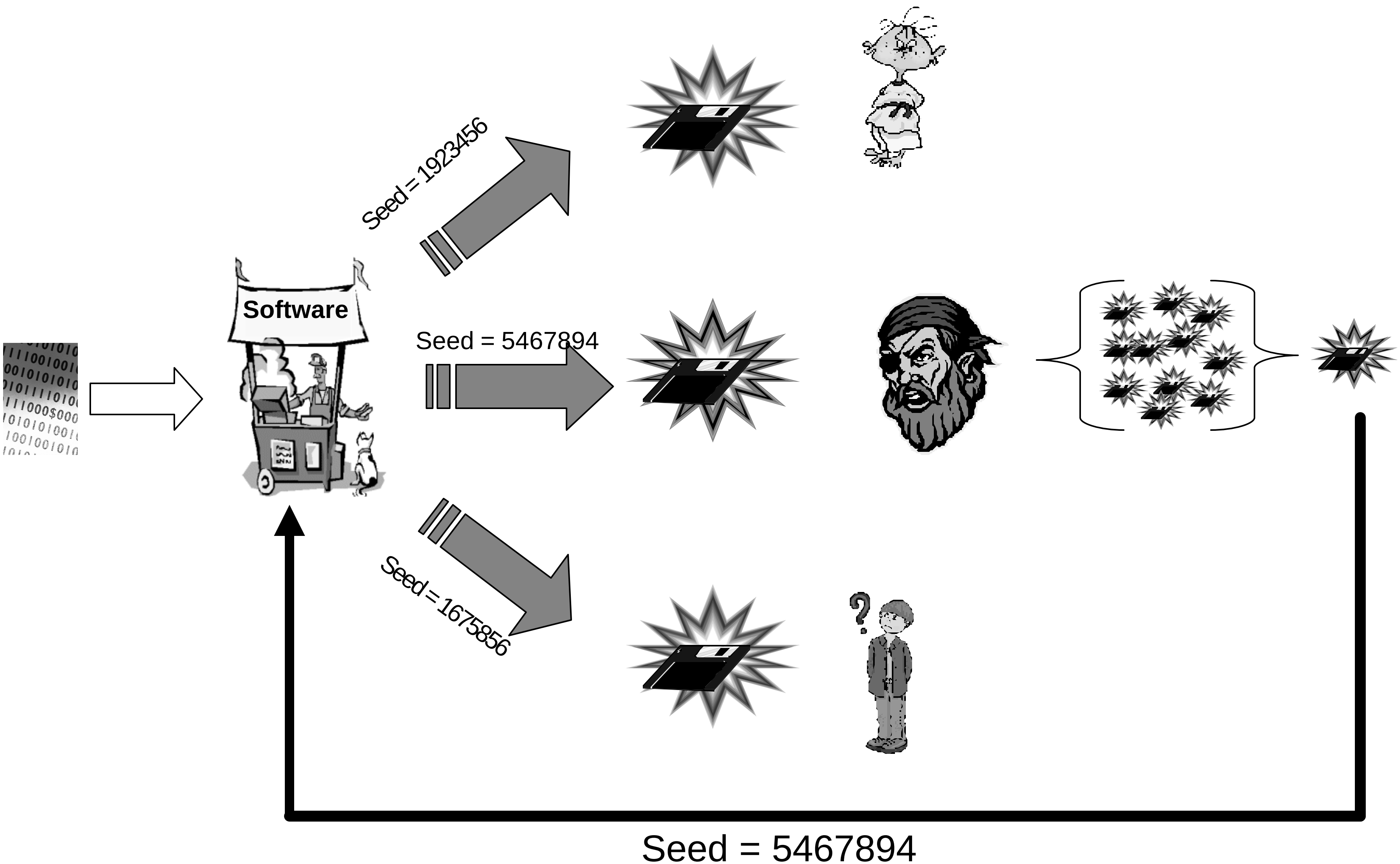
Code Obfuscation

Digital Rights Management

Tamper -Proofing

Watermarking

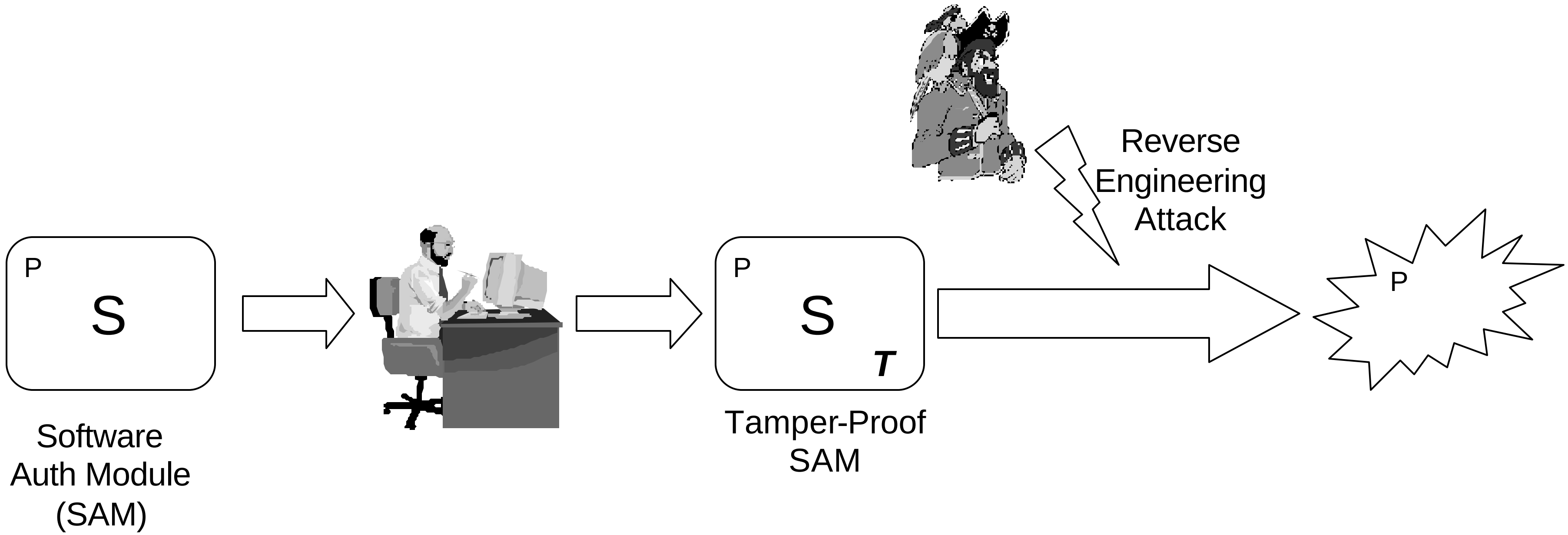
Watermarking



Tamper - Proofing

- Key component of client-side security
- User is assumed to have sufficient time, resources and inclination to subvert protection
- www.cracks.am
- Demonstrates need for stronger protection against reverse engineering

Tamper-Proofing



Commercial Applications

- Code Obfuscators
  - Zelix Klassmaster
  - Semantic Design
- Digital Rights Management
  - Windows RMS Lockbox
  - Apple’s iTunes
- Tamper Proofing
  - Cloakware
- Watermarking
  - Digimarc

Conclusion

- Malicious host presents new security threats
- Code obfuscation makes reverse engineering difficult
- Watermarking and tamper-proofing address issues of software piracy and tampering respectively
- Still an inchoative field

References

[1] Collberg, C., Thomberson, C., Low, D., *A Taxonomy of Obfuscating Transformation*, Technical Report # 148, 1997

[2] Wang, C., *A Security Architecture of Survivability Mechanisms*, PhD thesis, University of Virginia, October 2000

[3] Wroblewski, G., *General Method of Program Code Obfuscation*, Wrowclaw, 2002

[4] Collberg, C., Thomberson, C., *Watermarking, Tamperproofing, and Obfuscation – Tools for Software protection*, 2002