StIns4CS: A State Inspection Tool for C#

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INTRODUCTION

Software Tampering

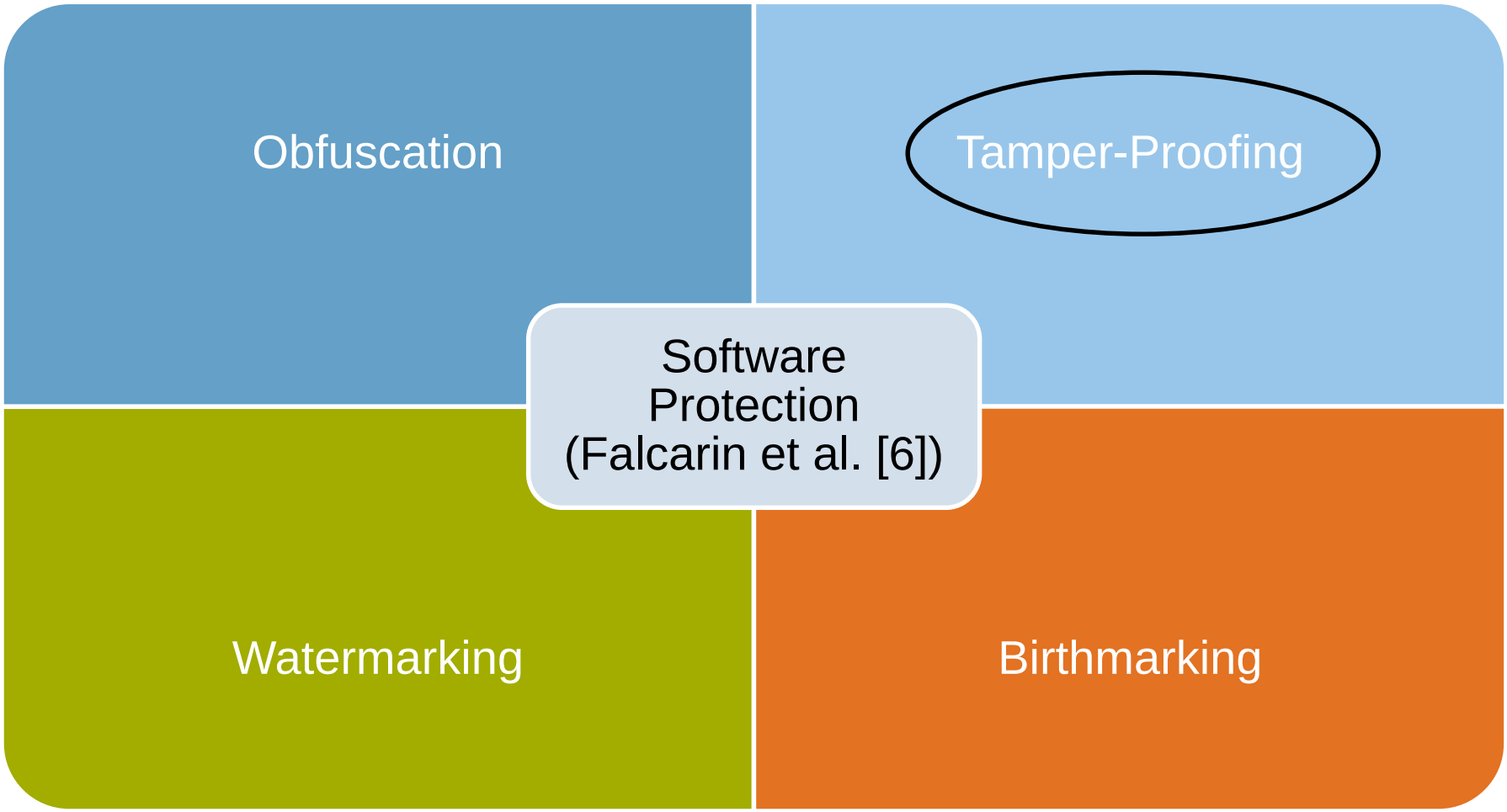
Context: Running an application on a platform controlled by an adversary

Attacks: Unauthorized modification of software

Consequence: Retail value of pirated software is $63 billion in 2013 [13]

```
1 public float sum(float [] arr){
2  float sum = 0;
3  for (int i = 0; i < arr.Length; i++){
4        // subtracts 0.00005
5        arr[i] = round(arr[i]);
6        sum += arr[i];
7 }
8 return sum;
9 }
```

How to protect a software



Contributions

- The design and implementation of StateInspection4CSharp tool.

- Symbolic execution to generate the set of input-output pairs for a certain set of functions.
- Evaluation of the performance and stealth of StIns4CS with various response mechanisms.
- A method to increase the stealth of the response mechanism by degrading results.

StIns4CS

The Concept

- State Inspection [4]
- Integrity of pure functions
- Random networks of guards
- A configurable response mechanism

Guard

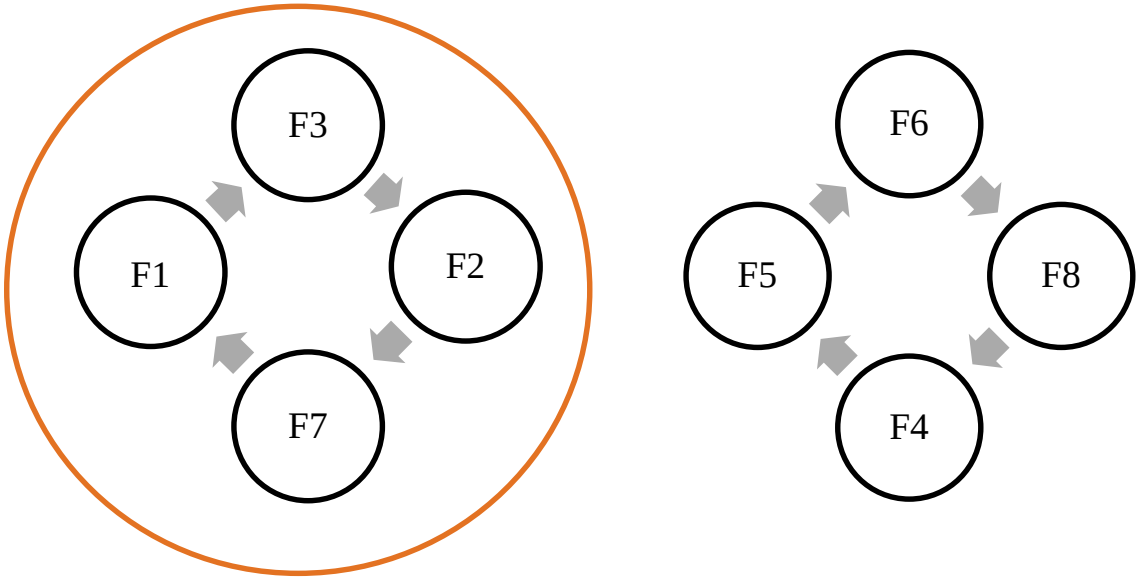
```
1 // Create an instance of the target class
2   A instance = new A();
3   var output;
4 // Invoke the checked function "f1"
5   output = instance.f1(param1);
6 // Compare against known value
7   if (output != expectedValue){
8         callResponse();
9   }
```

Code Guard Network

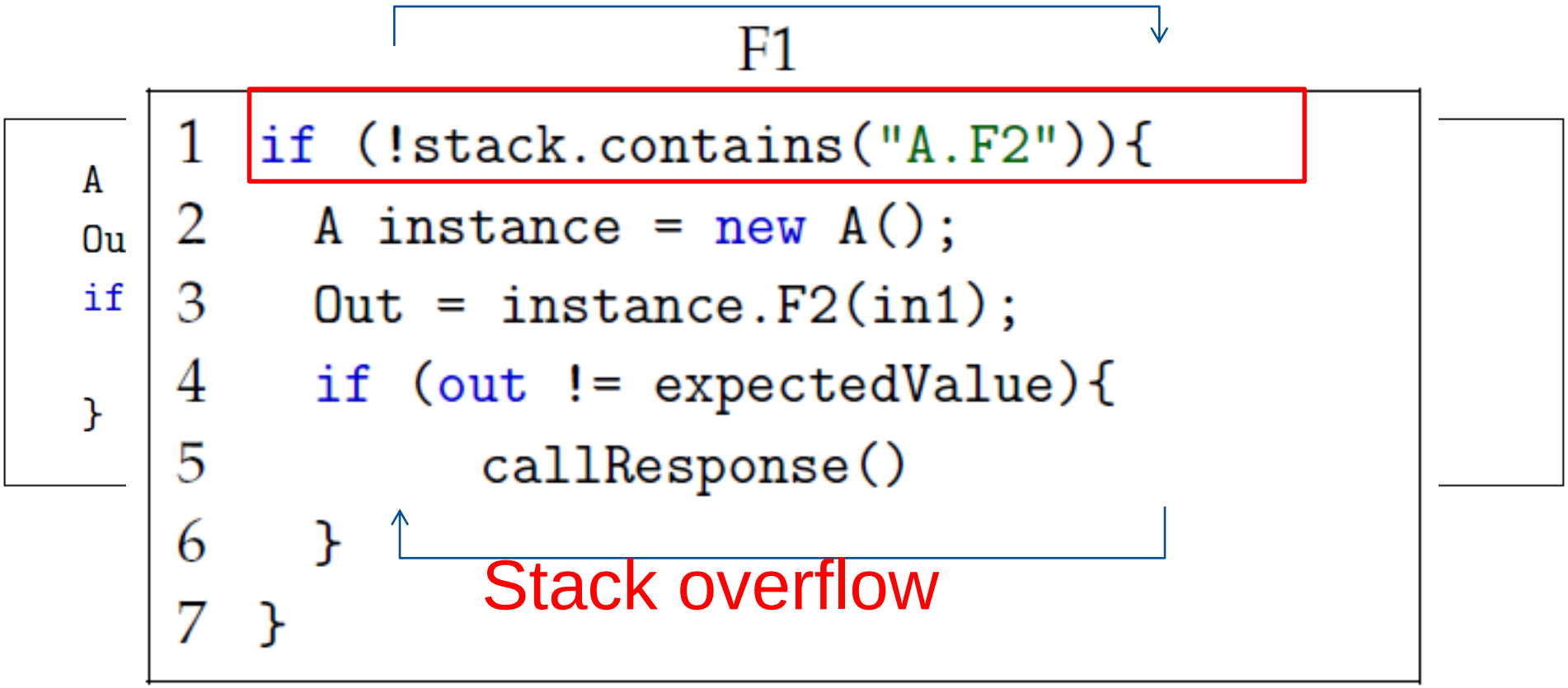
Original Methods

[F1, F2, F3, F4, F5, F6, F7, F8] → [F3, F2, F7, F1, F6, F8, F4, F5]

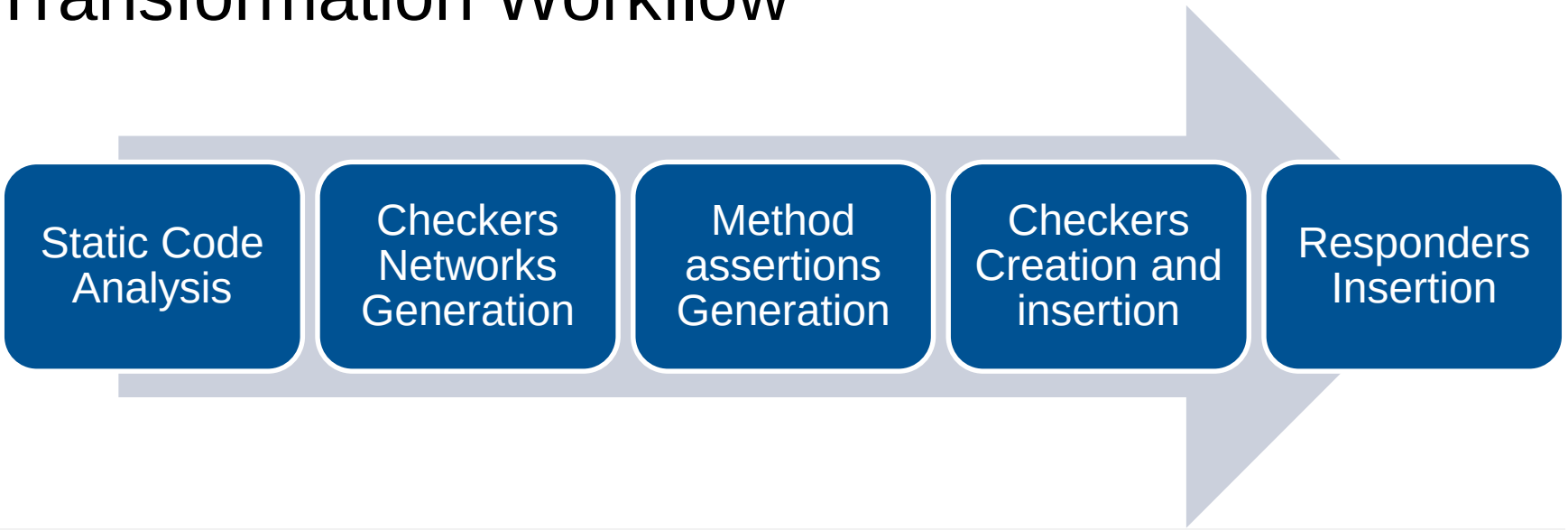
Shuffled Methods



Stack Inspection



Transformation Workflow



- Responses in case of detecting a tampering
  - Immediate crash
  - Delayed crash
  - Do nothing
  - Remote logging

Primitive combination

- Sabotaging the return values
- Incorporating results of the check with return value

Benefits

1. Hides the comparison
2. Hides the response
3. Adds diversity to the protection code

Primitive combination- Example

```
1 // Create an instance of the target class
2  A instance = new A();
3  var output;
4 // Invoke the checked function "f1"
5  output = instance.f1(param1);
```

```
return result.Substring(expected-output);
```

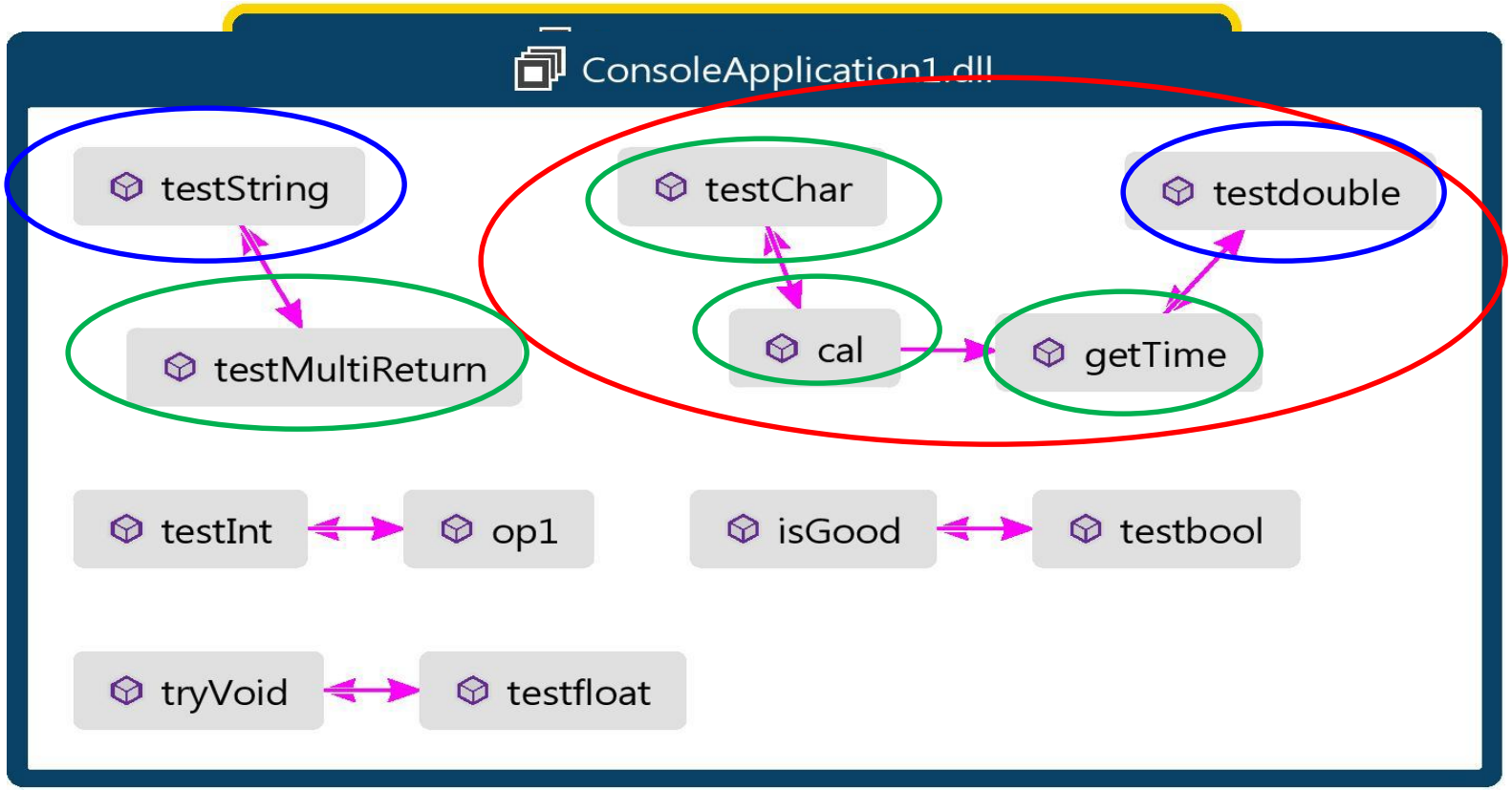
EVALUATION

- Effectiveness against static and dynamic patching
- Stealth of checking code
- Cost of checking

Effectiveness against code patching

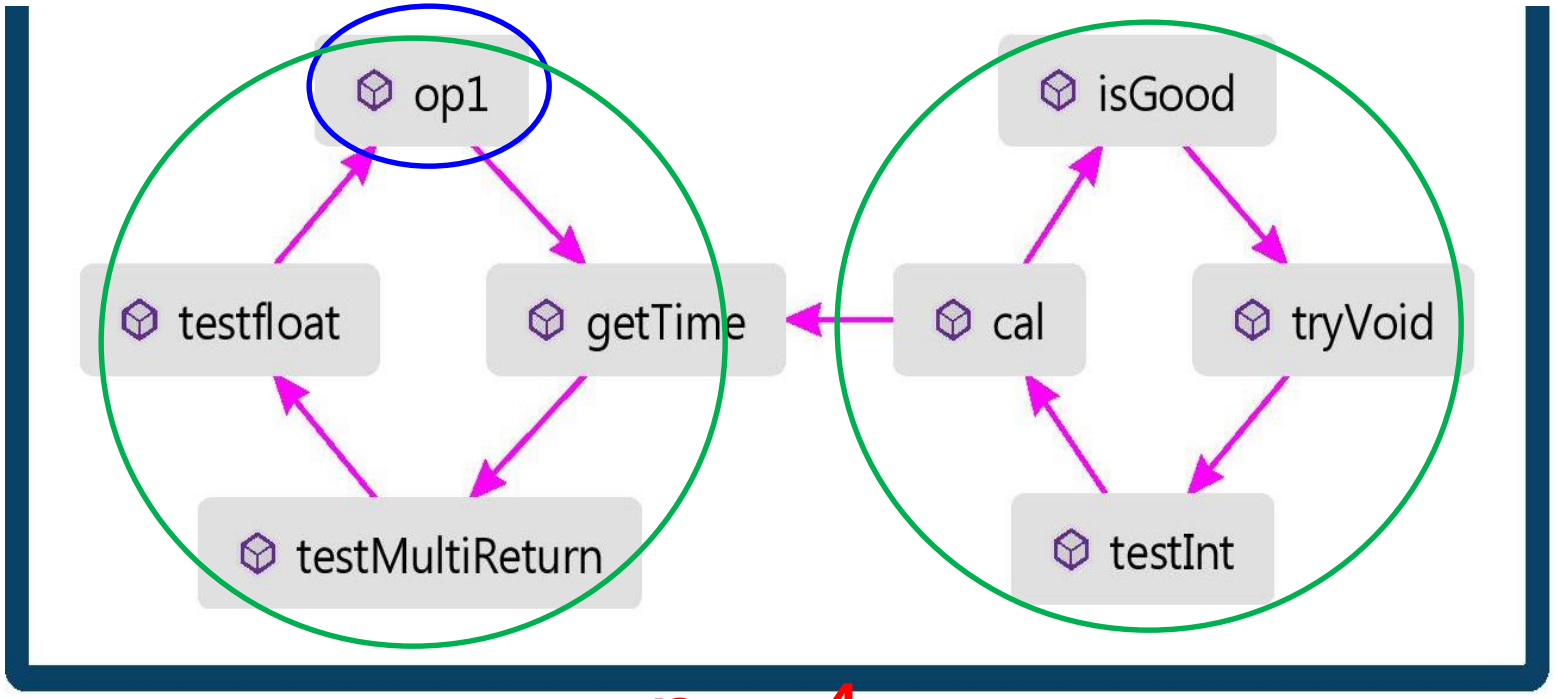
- Verify how the applications respond to patching
  - Static code patching
  - Dynamic memory patching
- Test variable:
  - Component size

Discussion



n = 2

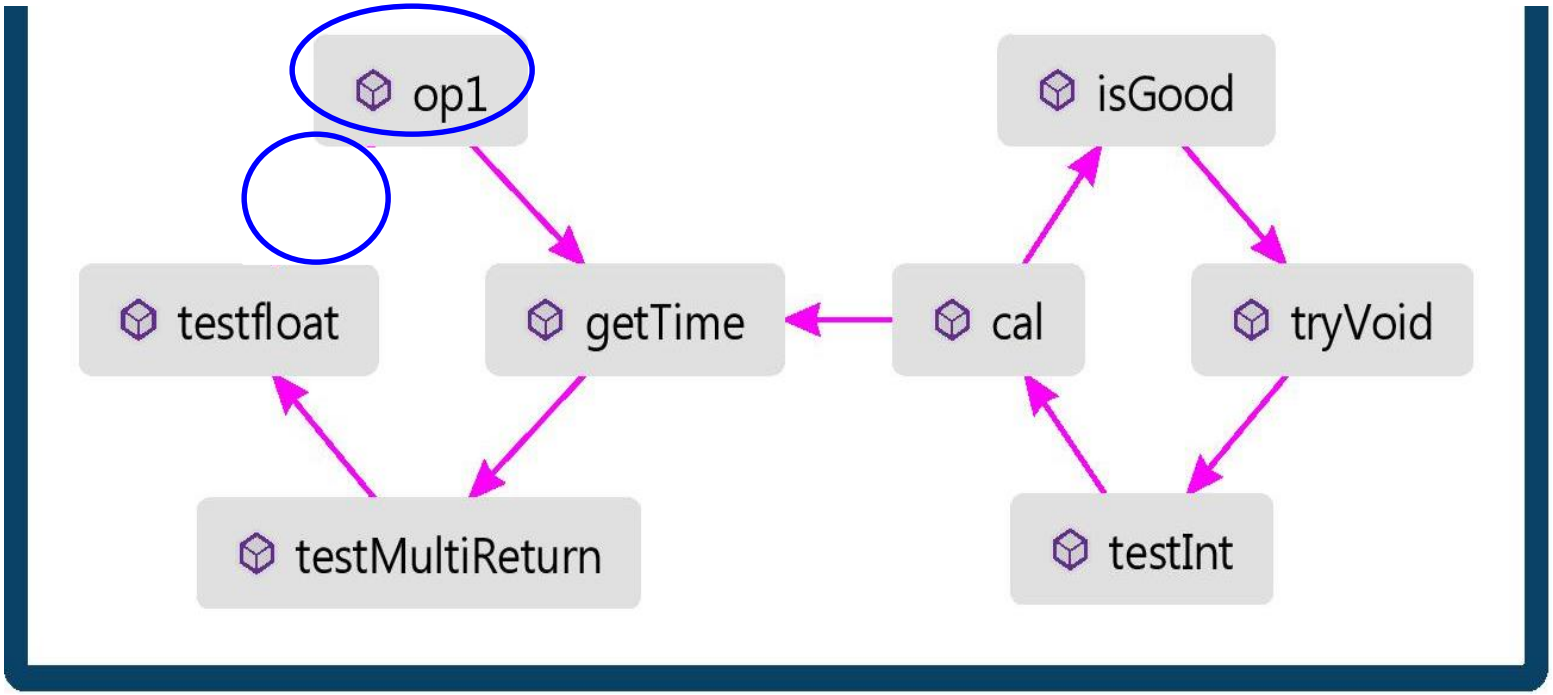
Discussion



n = 4

Patching detected in at least n-1 places

Disabling a check



n = 4

Stealth of checking code

- Pattern matching attacks
- Test variables
  - Primitive combination
  - Virtualization obfuscation
- Three regular expressions:
  - Regex1: any if-statement
  - Regex2: if-statement with stack inspection
  - Regex3: response call statement

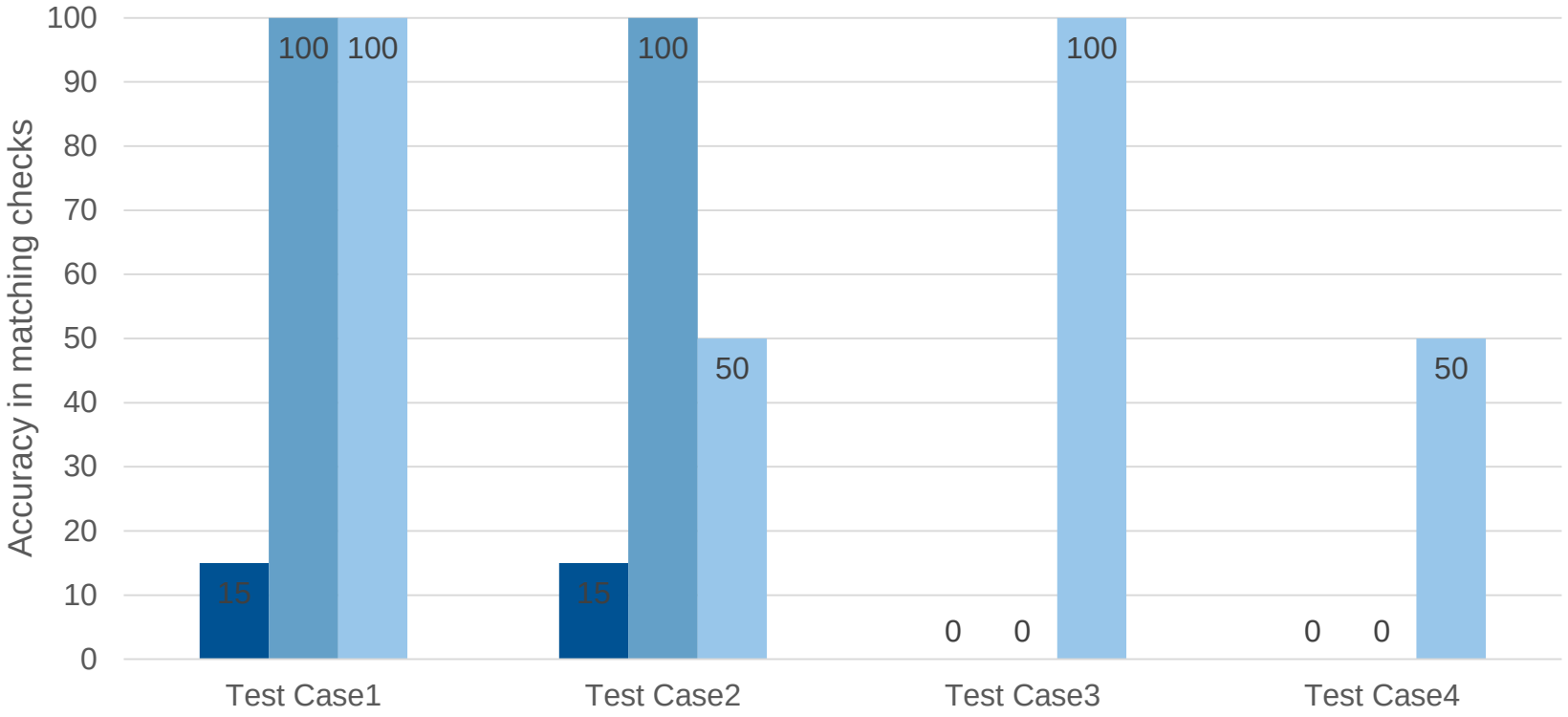
Discussion

Regex1 Regex2 Regex3

F1

```
1  if (!stack.contains("A.F2")){
2     A instance = new A();
3     Out = instance.F2(in1);
4     if (out != expectedValue){
5           callResponse()
6     }
7  }
```

Results

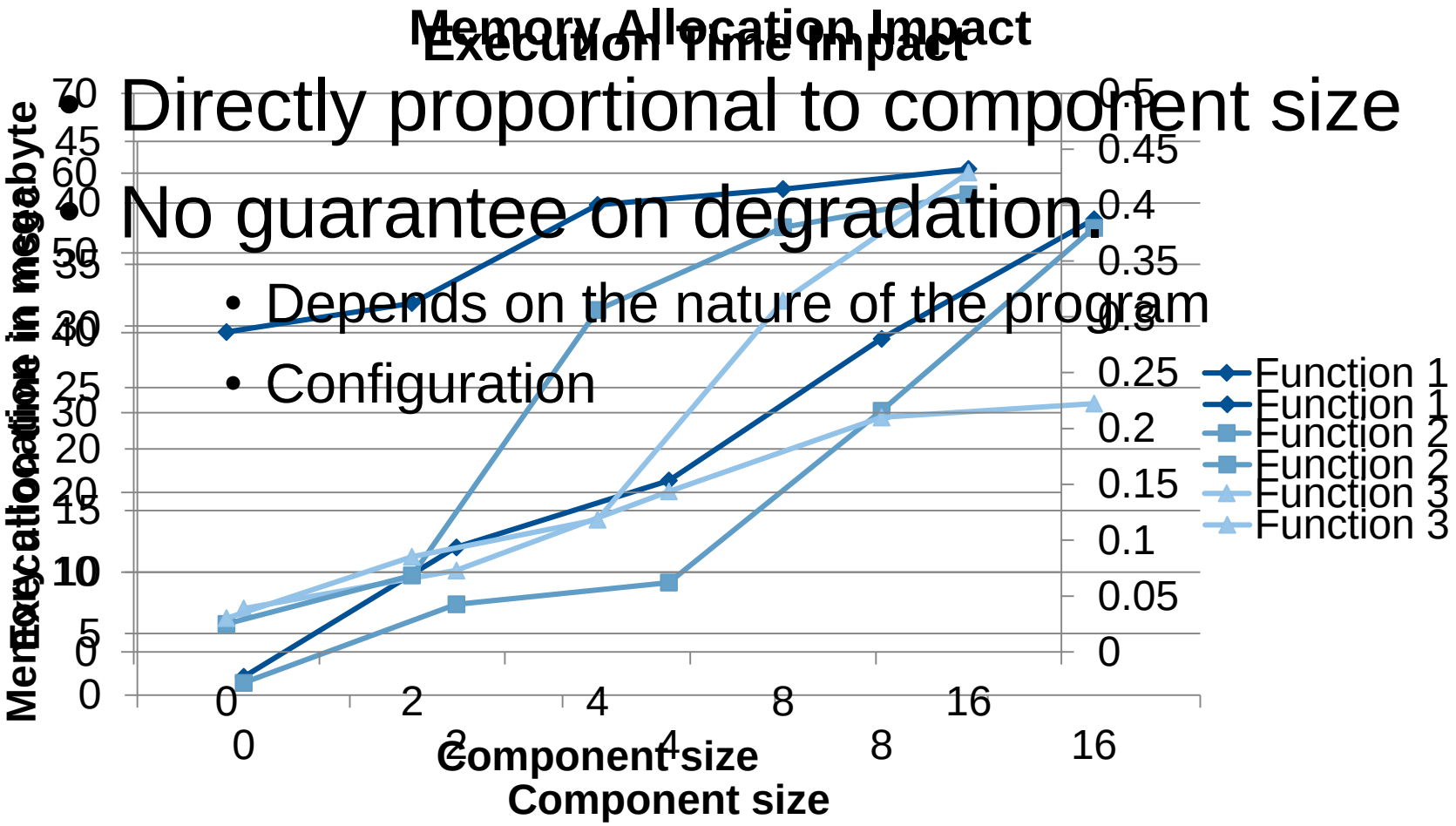


Name	Primitive_Combination	Virtualization
Test case 1	No	No
Test case 2	YES	No
Test case 3	No	YES
Test case 4	YES	YES

Cost of checking

- Function invocations added
  → performance will be affected
  - Execution time
  - Memory allocation
  - Code size

Execution time and memory allocation



Directly proportional to component size

No guarantee on degradation.

- Depends on the nature of the program
- Configuration

CONCLUSION & FUTURE WORK

Conclusion

- Effectiveness of the approach
  - StIns4CS
- Solving problems affect stealth
  - Stack inspection
- Enhancing the stealth is possible
  - Primitive combination

Future work

- Stack inspection → other options to break cycles
  - Information from the code call graph
- Primitive combination is conditioned
  - Generalizing this concept
- Software-diversity techniques within the checks
  - Versions of the same test

Thanks for your attention

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QUESTIONS!

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