SMT Solvers in IT Security - Deobfuscating binary code with logic

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DISCLAIMER

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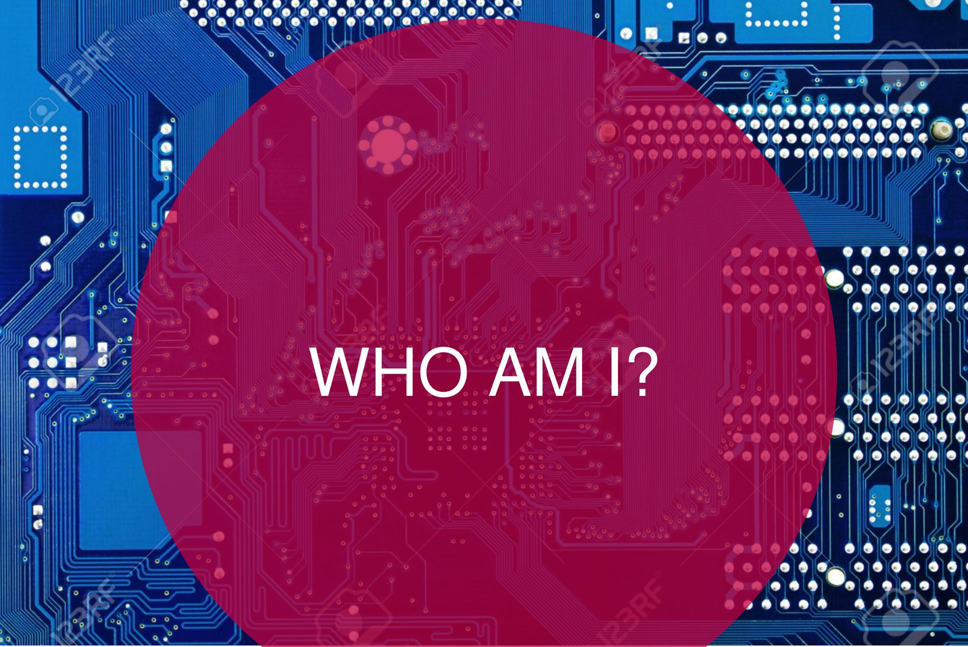
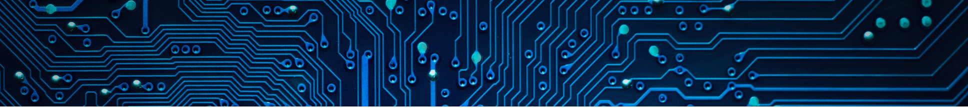
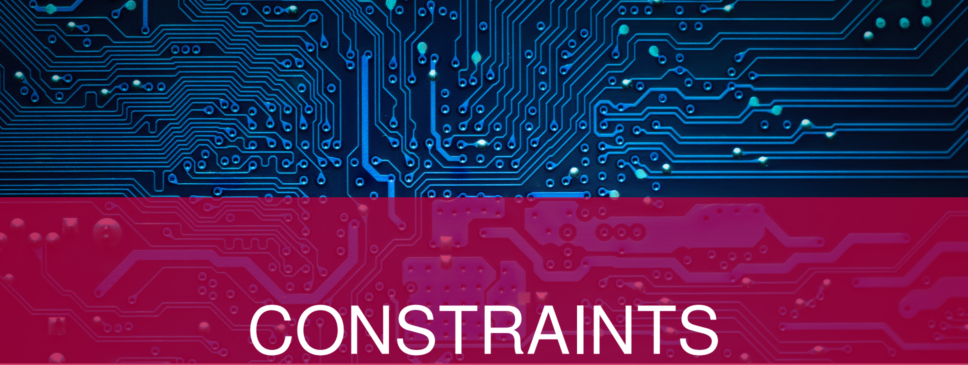


WHO AM I?

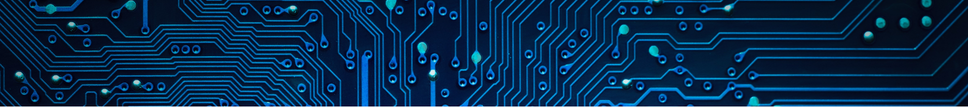


Overview:

- Introduction to Constraint Logic Programming
- Applications of CLP in IT Security
- Binary Obfuscation
- Malware deobfuscation using CLP

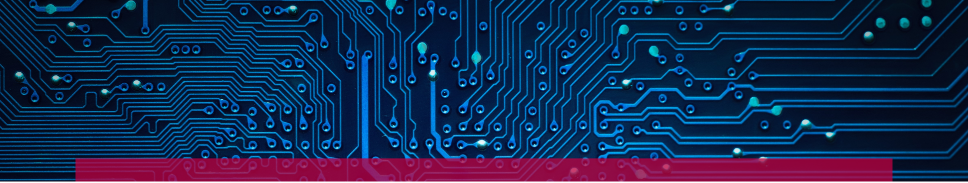


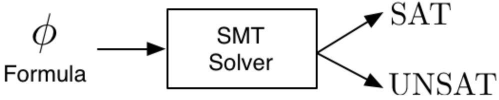
CONSTRAINTS



> ”Constraint programming represents one of the closest approaches computer science has yet made to the Holy Grail of programming: the user states the problem, the computer solves it.”

Eugene C. Freuder, Constraints, April 1997





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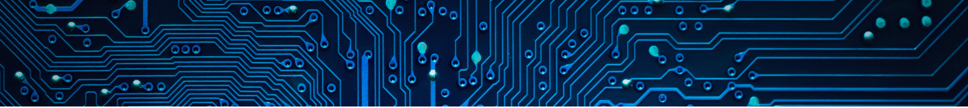
Formula

SMT Solver

SAT

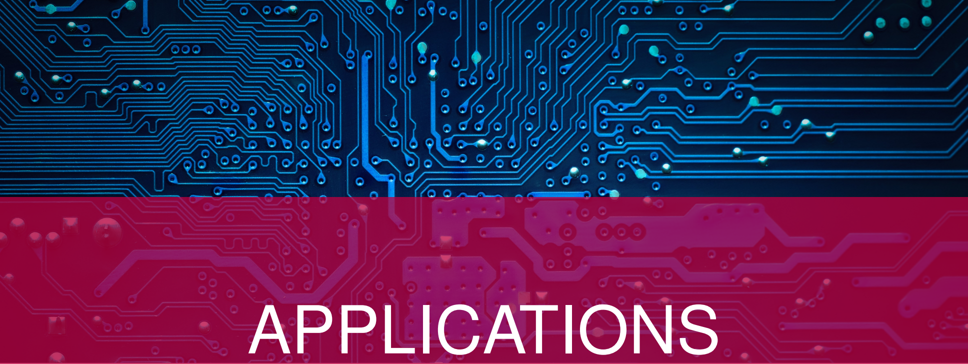
UNSAT



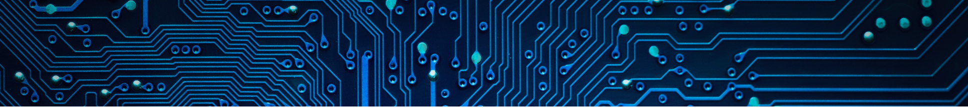
Automated Theorem Proving

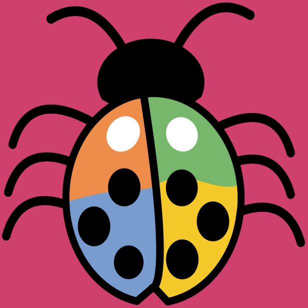
- Hardware and Software → Large-scale verification
- Languages specification and Computing proof obligations

SYMBOLIC EXECUTION



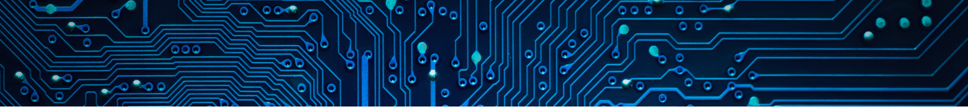
APPLICATIONS





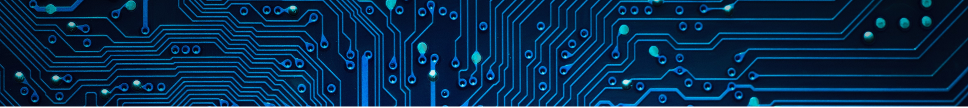
Bug Hunting

- Fuzzing
- Verification
- Analysis



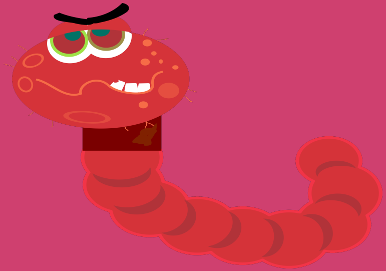
Exploit Generation

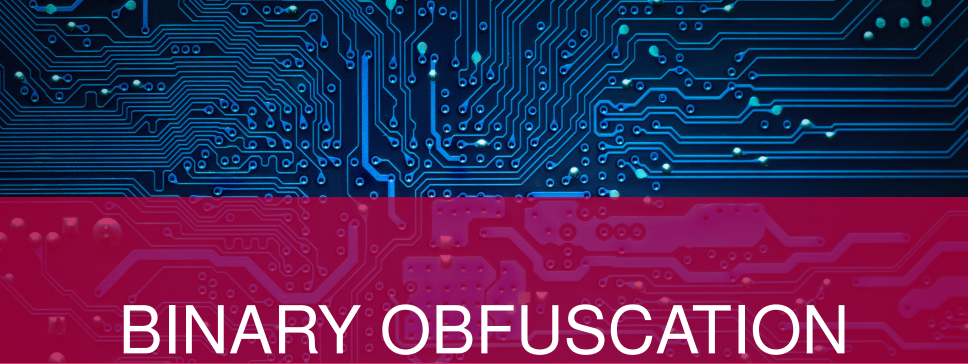
- Automatic Exploit Generation
- Proof of Concept
- Automatic Payload Generation



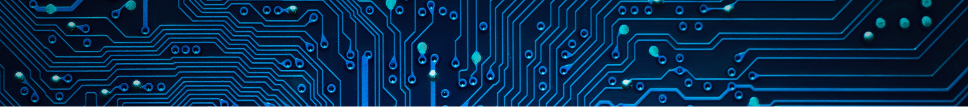
Malware Analysis

- Obfuscation
- Garbage-code elimination
- Compilation
- Packing
- Anti-debugging
- Crypto analysis



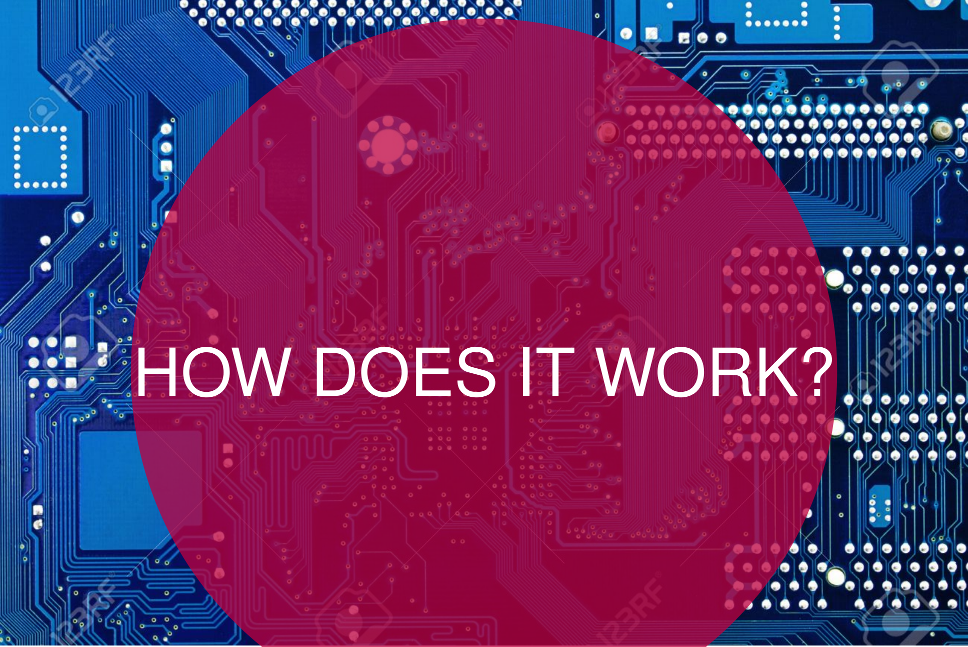


BINARY OBFUSCATION

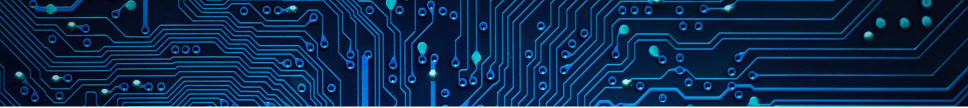


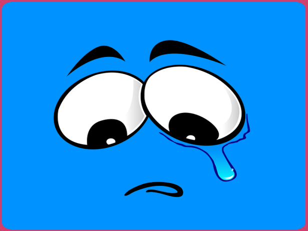
Malware Obfuscation

SW Property Protection

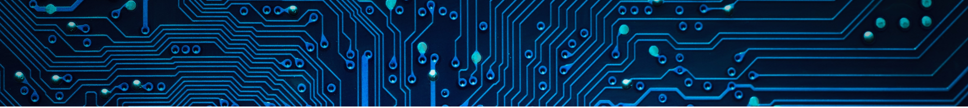


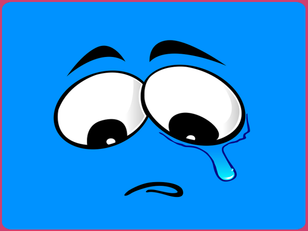
HOW DOES IT WORK?





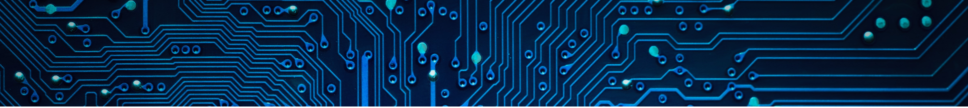
- Compiled
- Packed
- Obfuscated
- Anti-debugging

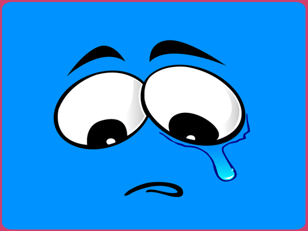




Garbage Code

- Unnecessary instructions
- Jumps that are never taken

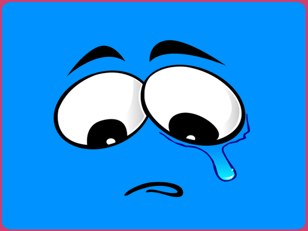


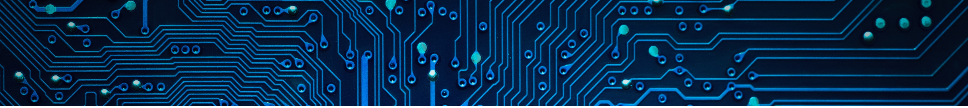


The exclusive or operation

Packers

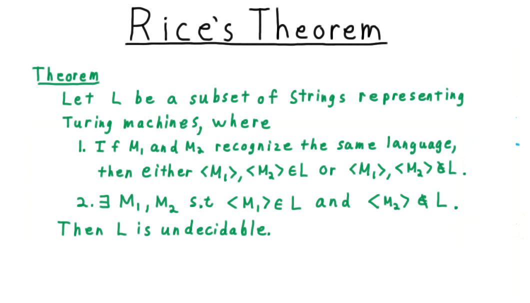
- UPX, NSIS
- self implemented





Malware Analysis

- Practical: Techniques to thwart analysis
- Theoretical: Rice's Theorem



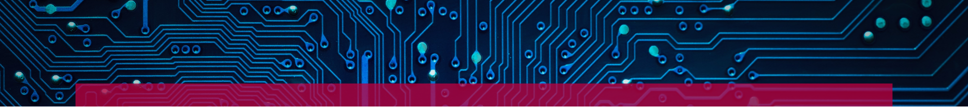
Rice's Theorem

Theorem

Let L be a subset of Strings representing Turing machines, where

1. If M_1 and M_2 recognize the same language, then either $\langle M_1 \rangle, \langle M_2 \rangle \in L$ or $\langle M_1 \rangle, \langle M_2 \rangle \notin L$.
2. $\exists\, M_1, M_2$ s.t $\langle M_1 \rangle \in L$ and $\langle M_2 \rangle \notin L$.

Then L is undecidable.



```
x = input();
x = x + 7;

if (x > 0)
y = input();
else
y = 11;

if (x > 2)
if (y == 42)
throw
  Exception()
```

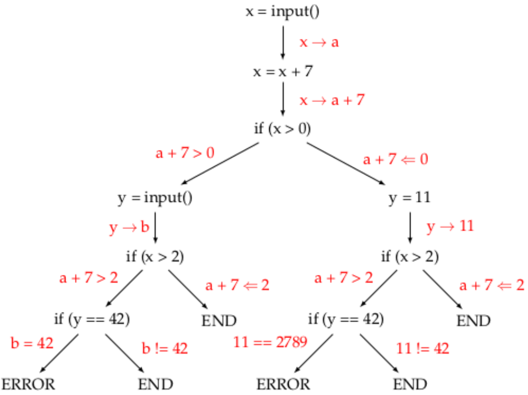
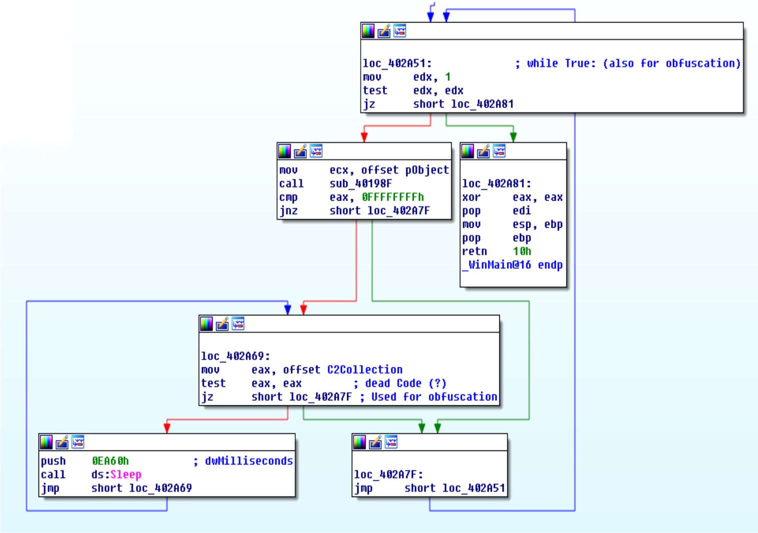


Figure 8: *Example of symbolic execution for simple program*

- Symbols as arguments

  ⇒ **any** feasible path
- Program states
  - Symbolic values for memory locations
  - Path conditions



```
loc_402A51:              ; while True: (also for obfuscation)
mov     edx, 1
test    edx, edx
jz      short loc_402A81
```

```
mov     ecx, offset pObject
call    sub_40198F
cmp     eax, 0FFFFFFFFh
jnz     short loc_402A7F
```

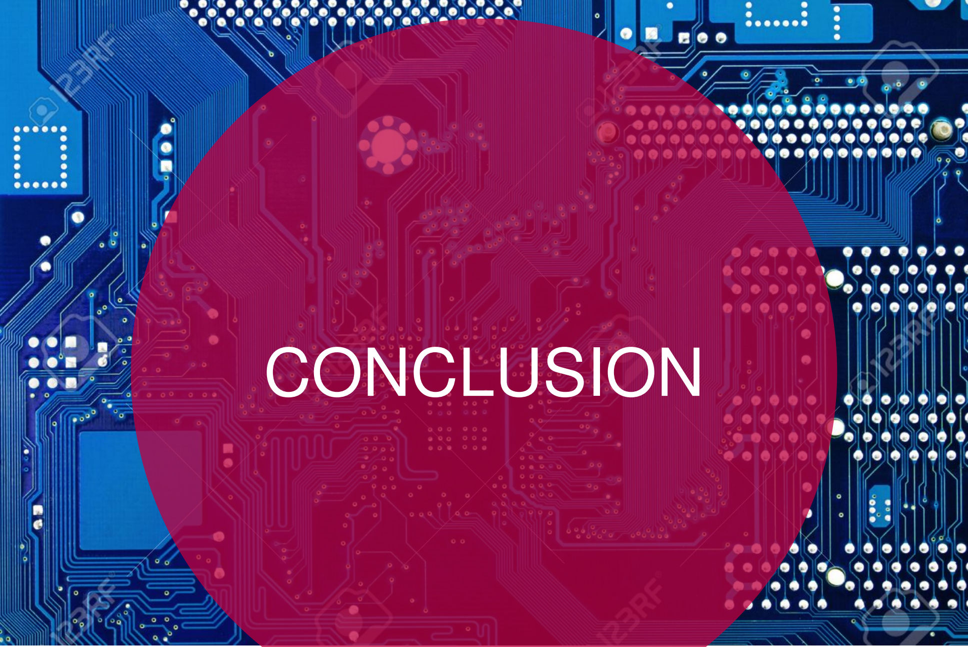
```
loc_402A81:
xor     eax, eax
pop     edi
mov     esp, ebp
pop     ebp
retn    10h
_WinMain@16 endp
```

```
loc_402A69:
mov     eax, offset C2Collection
test    eax, eax         ; dead Code (?)
jz      short loc_402A7F ; Used for obfuscation
```

```
push    0EA60h            ; dwMilliseconds
call    ds:Sleep
jmp     short loc_402A69
```

```
loc_402A7F:
jmp     short loc_402A51
```

CONCLUSION



THANK YOU!