

Taint Mechanisms

Advanced topics in Computer Security

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Outline

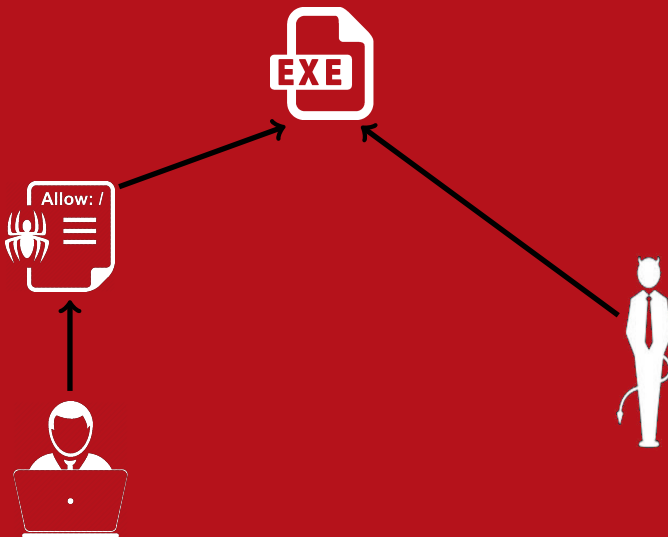
Introduction

Dynamic Taint Analysis

Forward Symbolic Execution

Conclusions

Of who or what do we trust?





Input Analysis

There are two essential questions about the input analysis:

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- **Dynamic Taint Analysis!**
- Tracks information flow between sources and sinks

Input Analysis

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1. **Is the final value affected by user input?**

- **Dynamic Taint Analysis!**
- Tracks information flow between sources and sinks

2. **What input will make execution reach this line of code?**

- **Forward Symbolic Execution**
- Allows us to reason about the behavior of a program on many different inputs

Dynamic Taint Analysis

```
x = get_input()
```

```
z = 42
```

```
y = x + z
```

```
goto y
```

Dynamic Taint Analysis

Tainted

 = get_input()

z = 42

y = x + z

goto y

x is derived from
a tainted source

Dynamic Taint Analysis

Untainted `x = get_input()`

`z` = 42

`y = x + z`

`goto y`

`z` is a "static"
constant

Dynamic Taint Analysis

```
x = get_input()
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→ Is y tainted?

```
goto y
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Dynamic Taint Analysis

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→ Is y tainted?

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```

It depends on the
selected policy

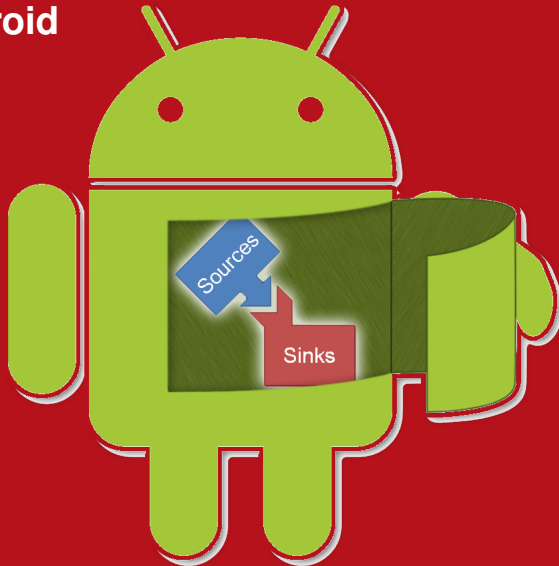
What's a policy?

- ▶ A taint policy specifies three properties:
 - **Taint Introduction**
 - ▶ How is taint introduced into a system?
 - **Taint Propagation**
 - ▶ How does taint propagate into a system?
 - **Taint Checking**
 - ▶ Is the current operation secure?

- ▶ **Undertainting vs Overtainting**

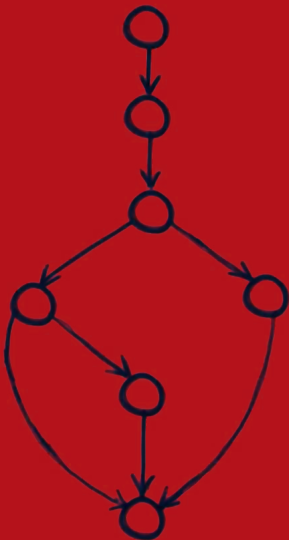
Can we go further?

TaintDroid



Limitations

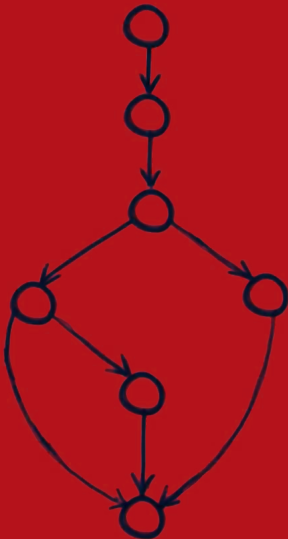
► Sanitization problem



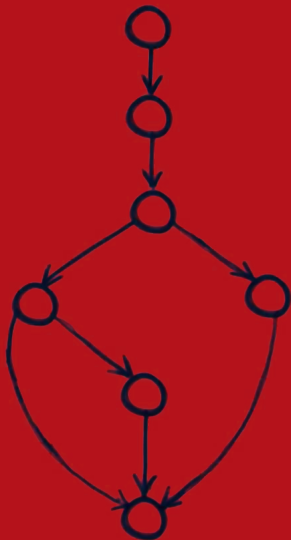
Limitations

► Sanitization problem

$$b := a \oplus a$$



Limitations



- ▶ **Sanitization problem**

$b := a \oplus a$

- ▶ Pure dynamic taint analysis considers **data flows...**

...but it ignores **control-flows**

```
x = get_input(src)
```

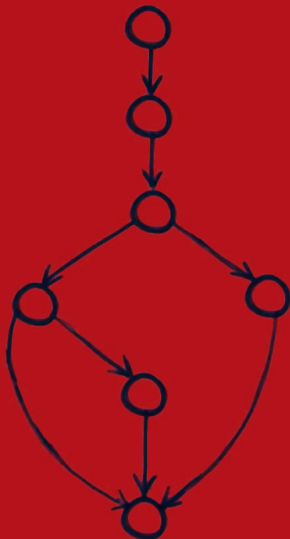
```
if x == 1 then
```

```
    y = 1
```

```
...
```

```
goto y
```


Limitations



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$b := a \oplus a$

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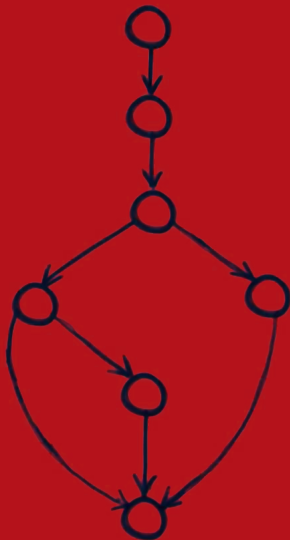
```
    y = 1
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- ▶ What about different security policies for different I/O channels?

Limitations



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- ▶ What about different security policies for different I/O channels?

→ **Static analysis**

Forward Symbolic Execution

- ▶ We can reason about the behavior of a program using the logic...
- ▶ ... and it is **conceptually** a very simple process

```
x = 2 * get_input(src)
if x - 5 == 14
    // catastrophic failure
// normal behavior
```

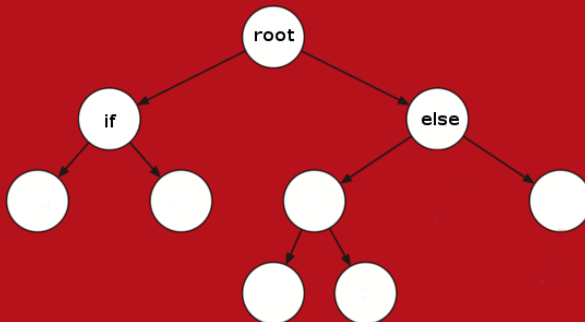
Forward Symbolic Execution

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```
x = 2 * get_input(src)
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    // catastrophic failure
    // normal behavior
```
- ▶ `get_input(src)` now returns a **symbol** instead of a concrete value
- ▶ But now expressions **cannot** be fully evaluated to a concrete value

Path Selection and Performance

- ▶ For each conditional jump we must decide what path to follow first
 - But some path may never terminate
- ▶ Exponential blowup due to branches



Solutions

- ▶ **Path Selection Heuristics**
 - Concolic Testing
 - Random Search
- ▶ More and faster **hardware**
- ▶ Identify **redundancies** between formulas
- ▶ Identify **independent subformulas**

Solutions

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...but solving a logical formula is a \mathcal{NP} -**Complete** problem!

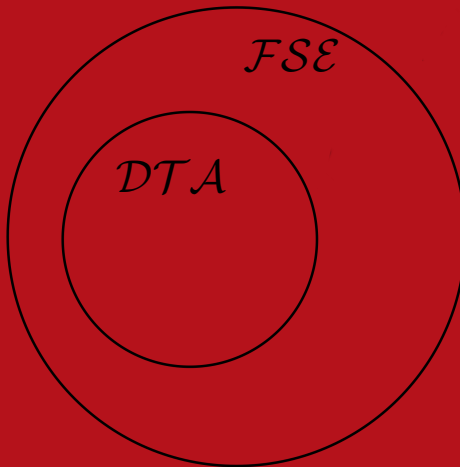
A small comparison

Dynamic
Taint
Analysis



Forward
Symbolic
Execution

A small comparison



Dynamic taint analysis analyzes only ***feasible*** paths

Conclusions

- ✓ Conceptually simple methods of analysis
- ✓ There are a lot of possible use cases
 - Malware detection and analysis
 - Automatic testing
 - Automatic programs understanding
- x Usable with some care
- x The effectiveness depends on the application



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Thank you for allowing me to
taint your time!

Questions?



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MATEMATICA