0-Knowledge Fuzzing

Vincenzo Iozzo

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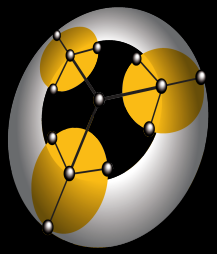

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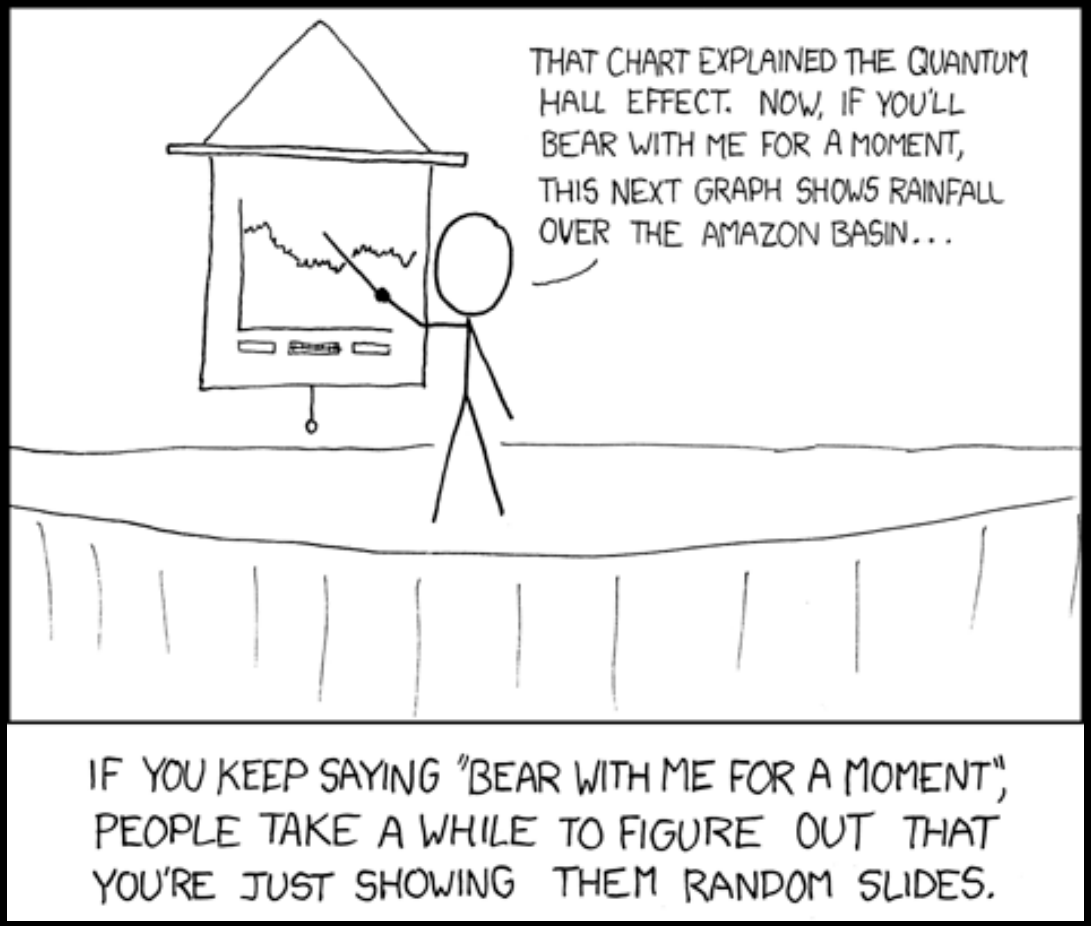
Disclaimer

- In this talk you won't see all those formulas [illegible]tion, code snippets and bullets.
- From past experiences the speak[illegible]t all the aforementioned elements are no useful i[illegible]ple understand your idea.
- You instead will see a[illegible]pictures which the speaker hopes will convey bett[illegible]anding of the ideas explained in the talk

$$(S_N f)(x) = \frac{a_0}{2} + \sum_{n=1}^{N} [a_n \cos(nx) + b_n \sin(nx)], \quad N \geq 0.$$

You don't want slides like this, do you?

Motivations



Questions!

Fuzzing

How it used to be

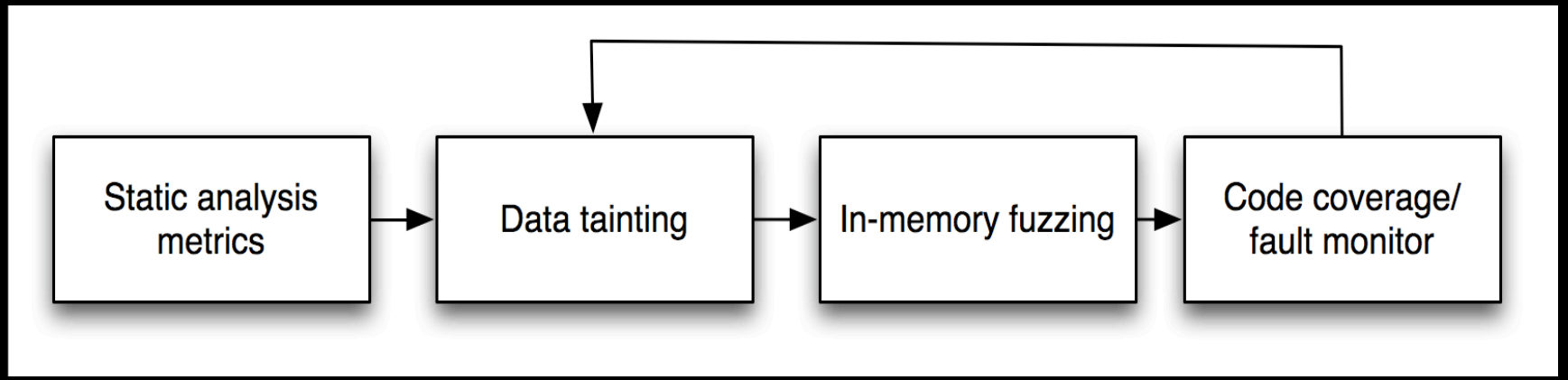
How it is today
(aka the reason of this talk)

Dumb fuzzing

Smart Fuzzing

Evolutionary Based Fuzzing

The idea

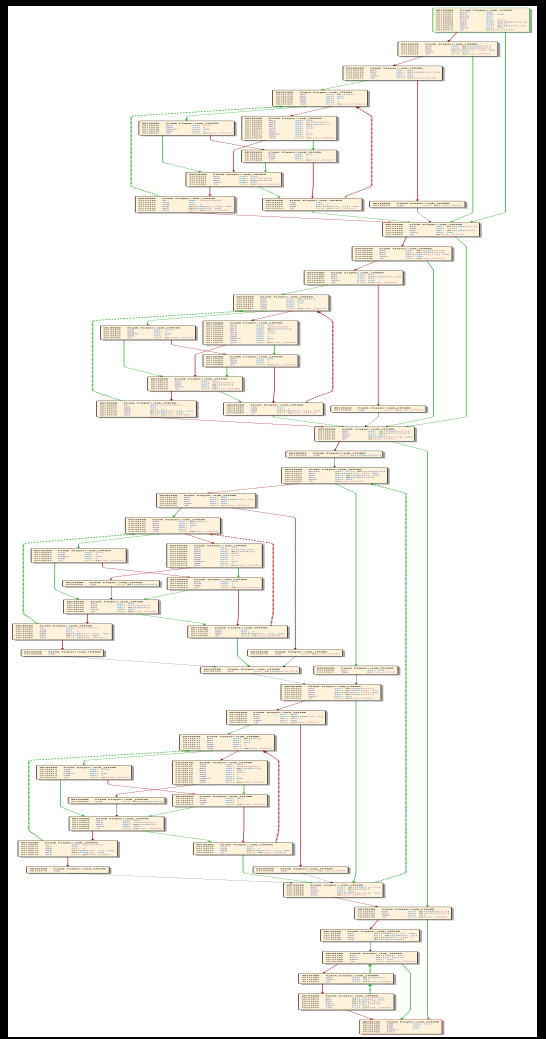

Static analysis metrics
Data tainting
In-memory fuzzing
Code coverage/ fault monitor

The surface

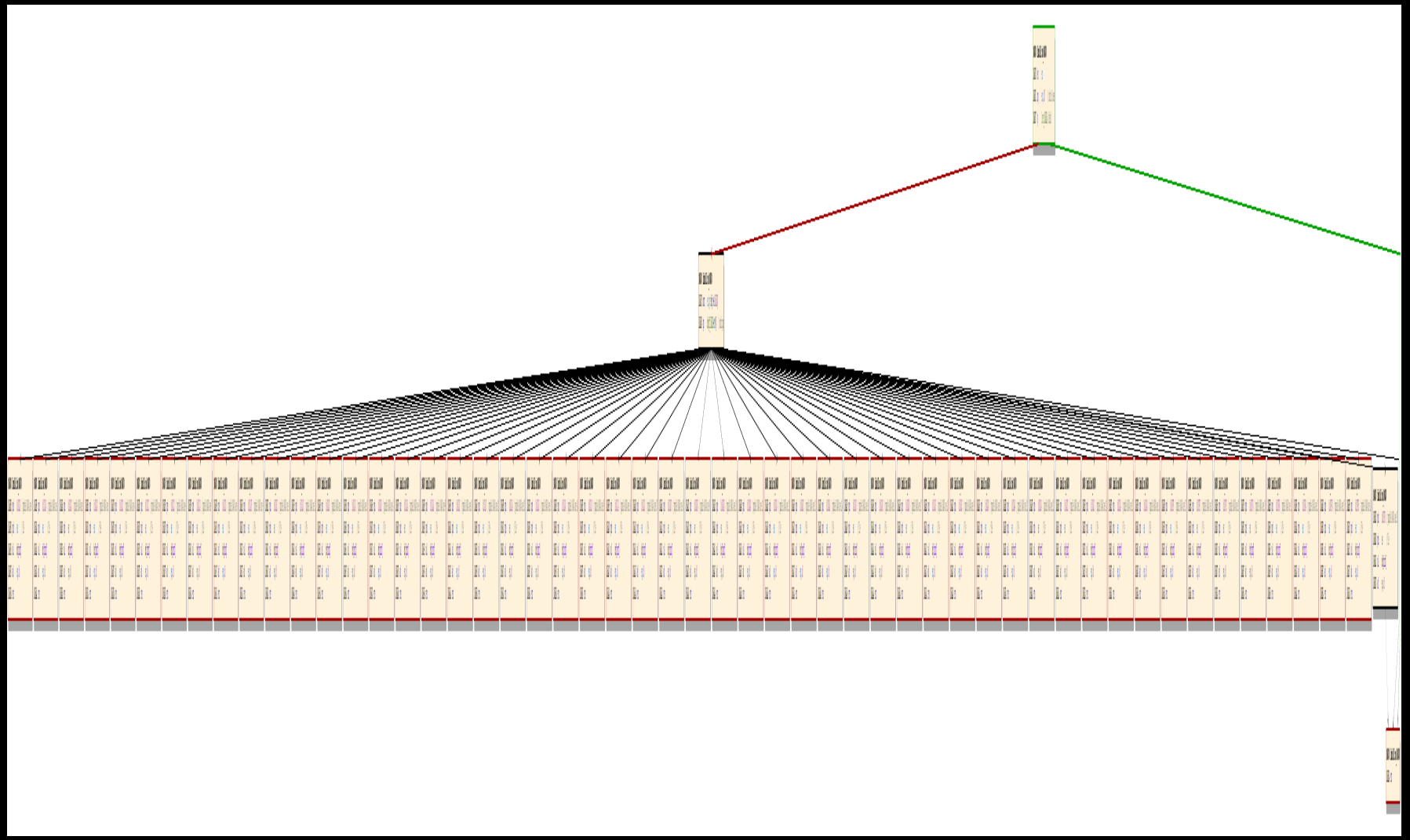
We need a filter

Cyclomatic complexity

This one

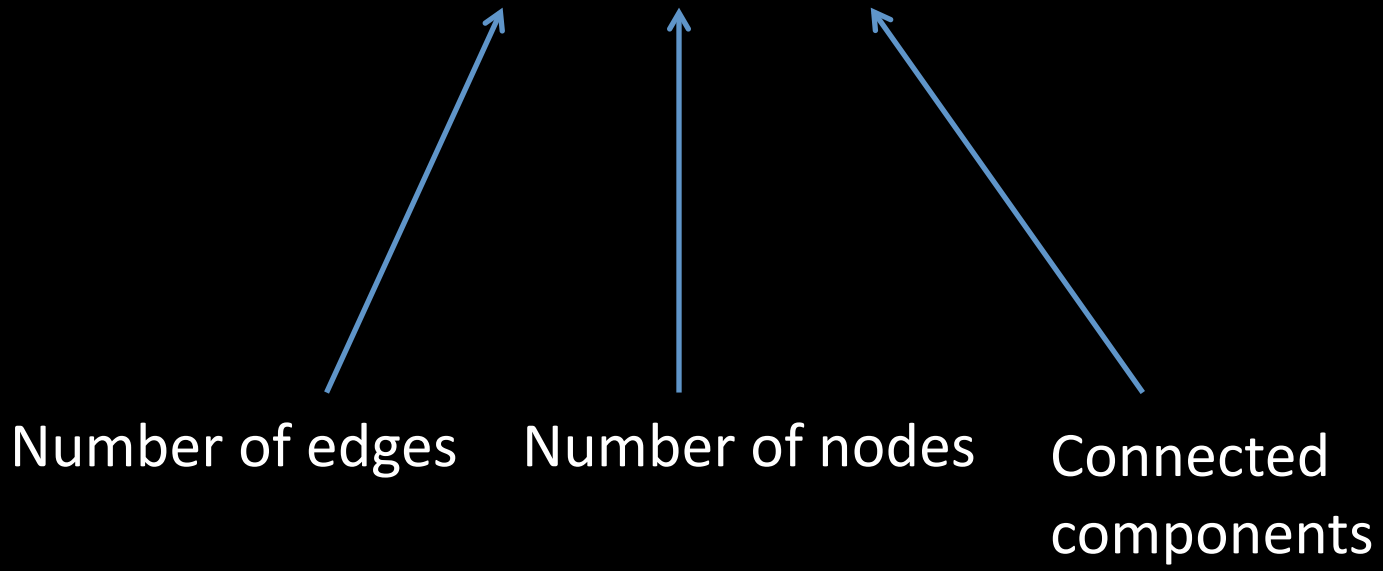


Not this one



Original formula

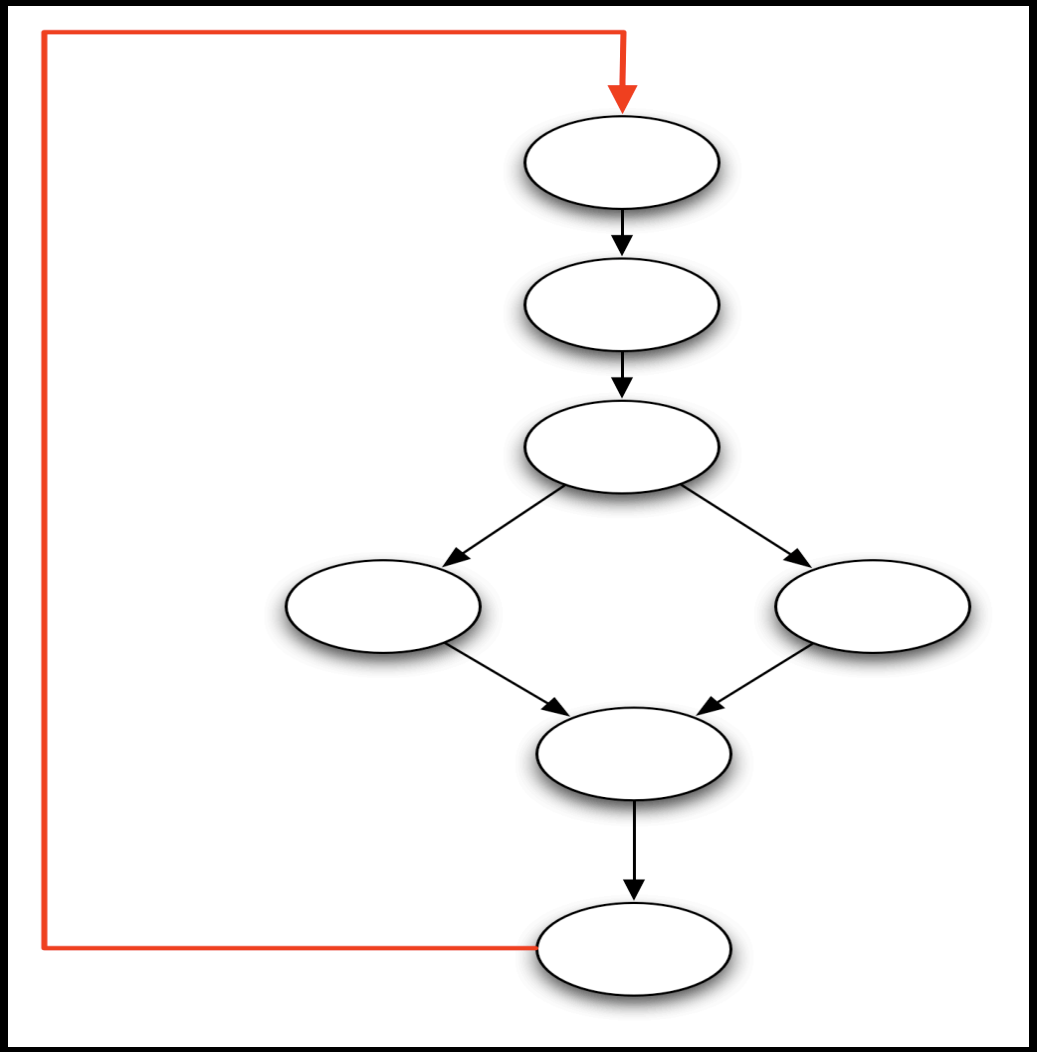
$$M = E - N + 2P$$



Why? Cyclomatic number

$$M = E - N + P$$

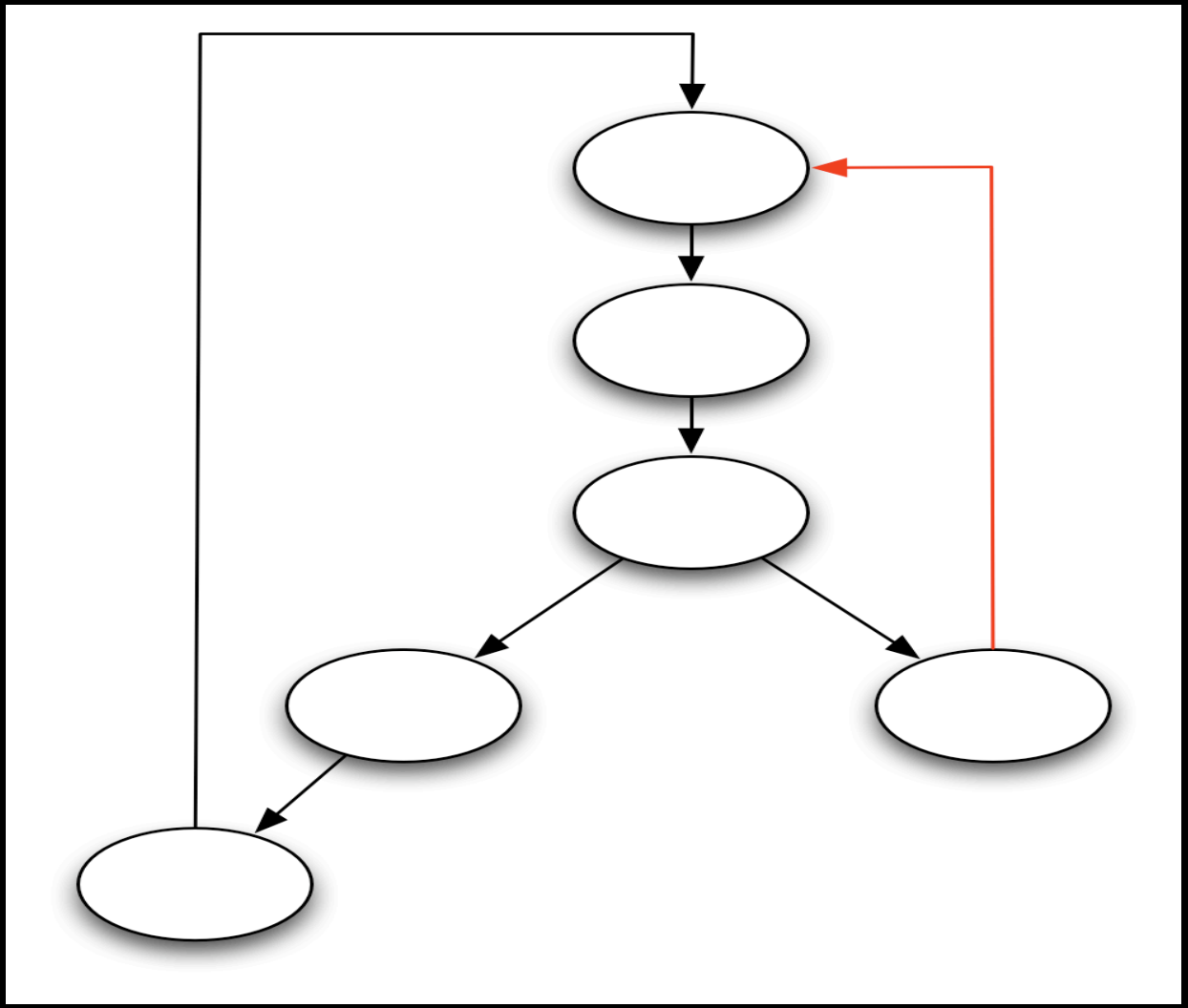
Simplify



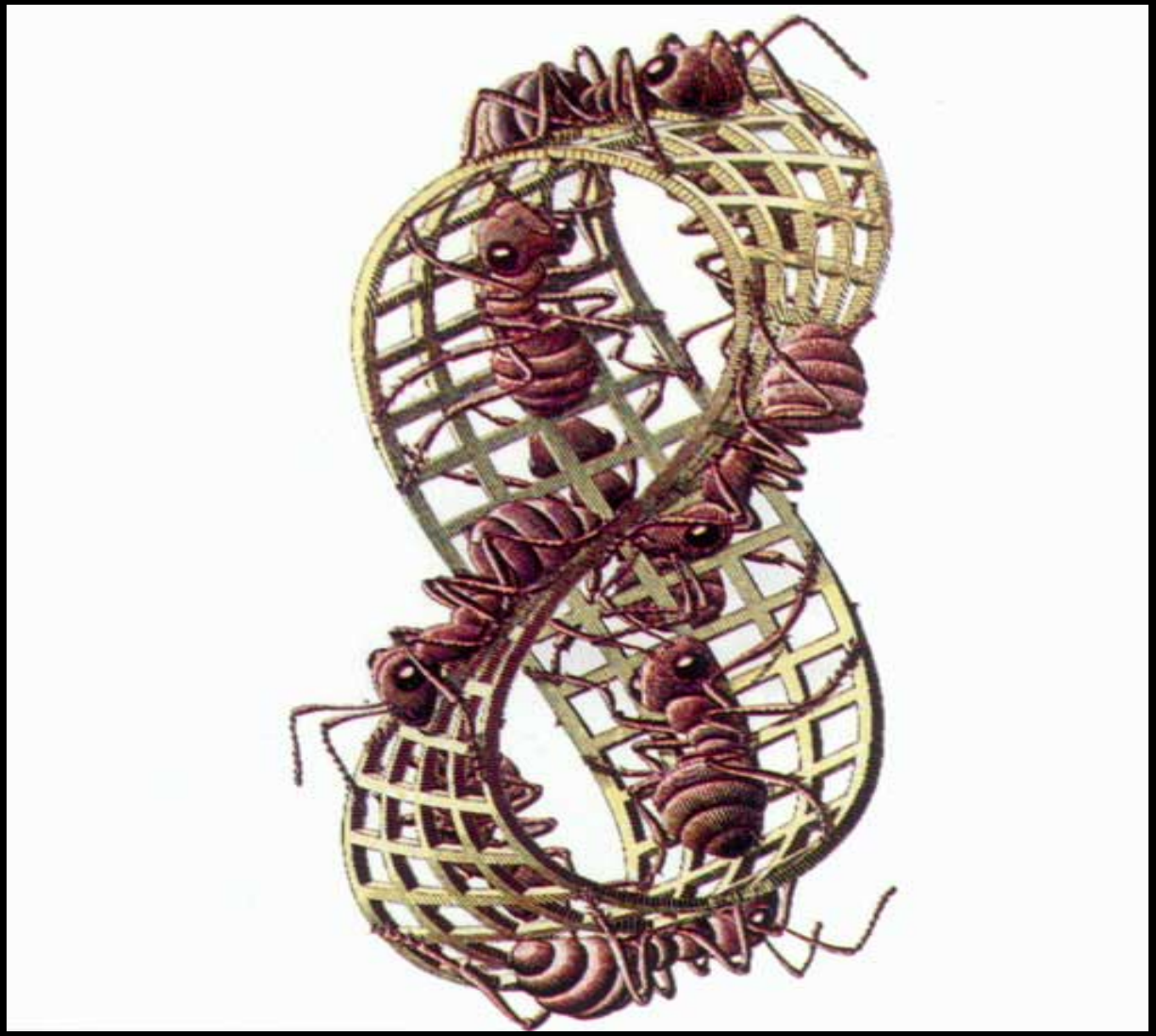
Formula

$$M = E - N + 2$$

Problem

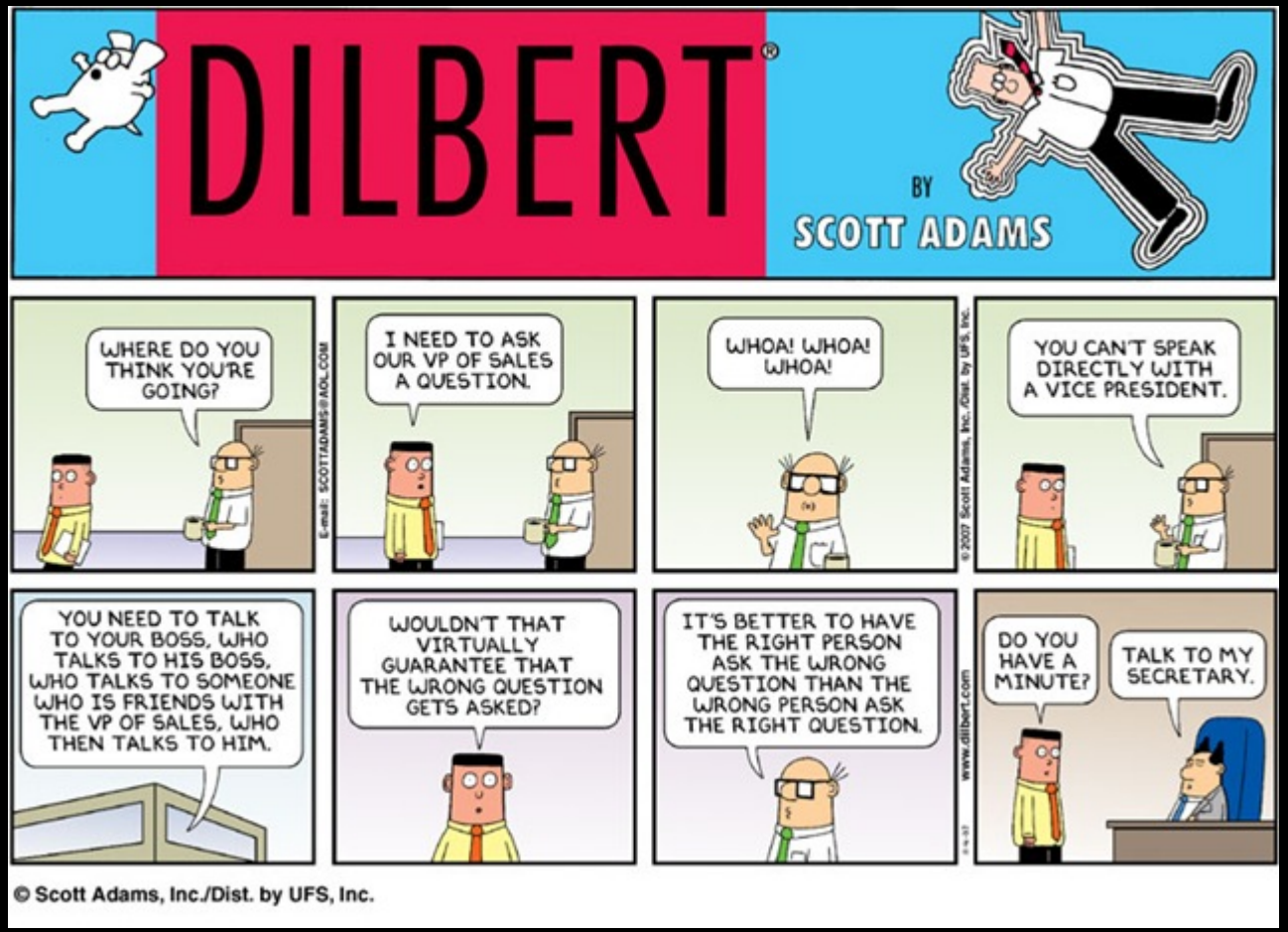


Loop detection

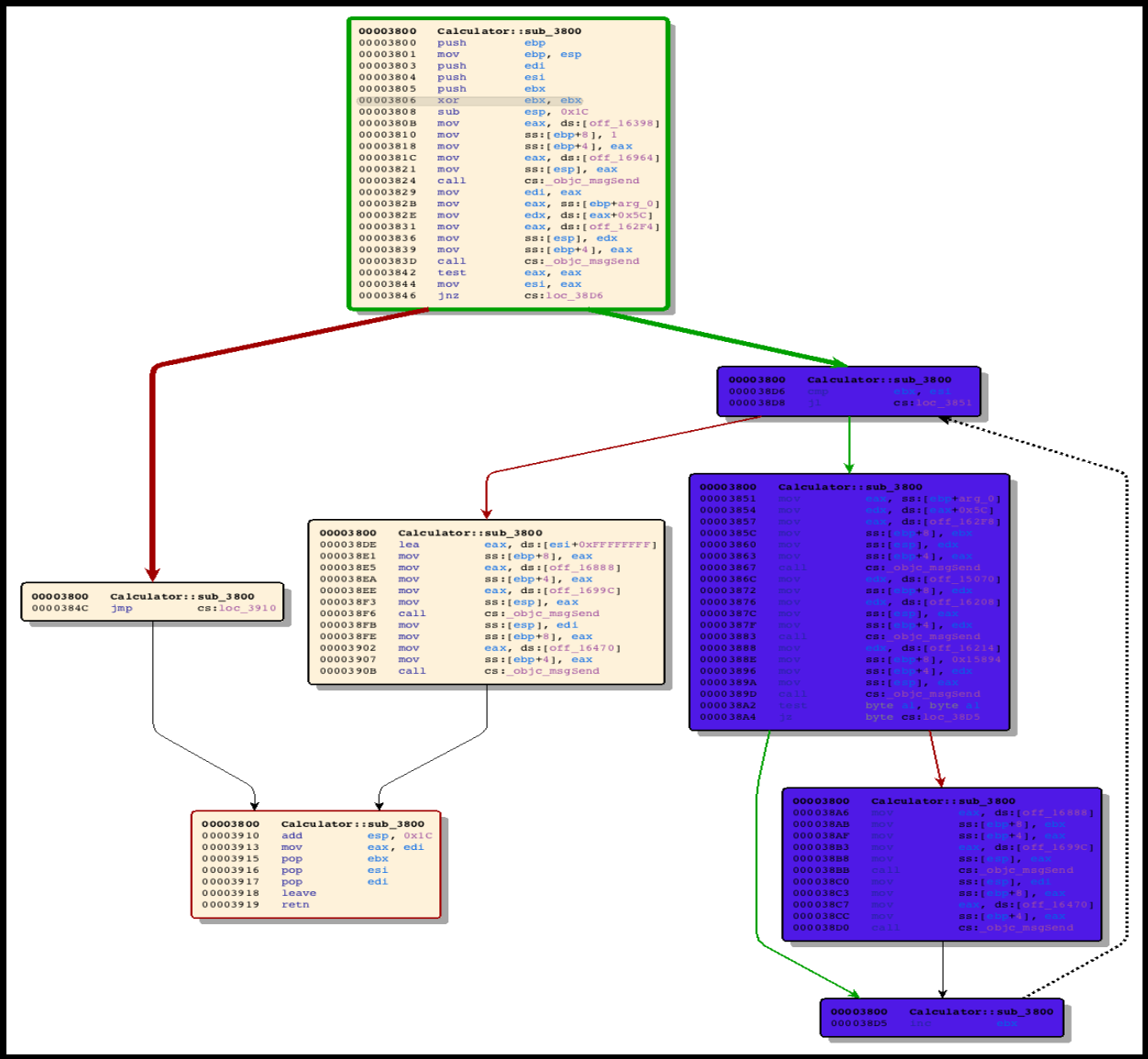


Dominator tree

Dominators


DILBERT
BY
SCOTT ADAMS
WHERE DO YOU THINK YOU'RE GOING?
I NEED TO ASK OUR VP OF SALES A QUESTION.
WHOA! WHOA! WHOA!
YOU CAN'T SPEAK DIRECTLY WITH A VICE PRESIDENT.
YOU NEED TO TALK TO YOUR BOSS, WHO TALKS TO HIS BOSS, WHO TALKS TO SOMEONE WHO IS FRIENDS WITH THE VP OF SALES, WHO THEN TALKS TO HIM.
WOULDN'T THAT VIRTUALLY GUARANTEE THAT THE WRONG QUESTION GETS ASKED?
IT'S BETTER TO HAVE THE RIGHT PERSON ASK THE WRONG QUESTION THAN THE WRONG PERSON ASK THE RIGHT QUESTION.
DO YOU HAVE A MINUTE?
TALK TO MY SECRETARY.
© Scott Adams, Inc./Dist. by UFS, Inc.

Function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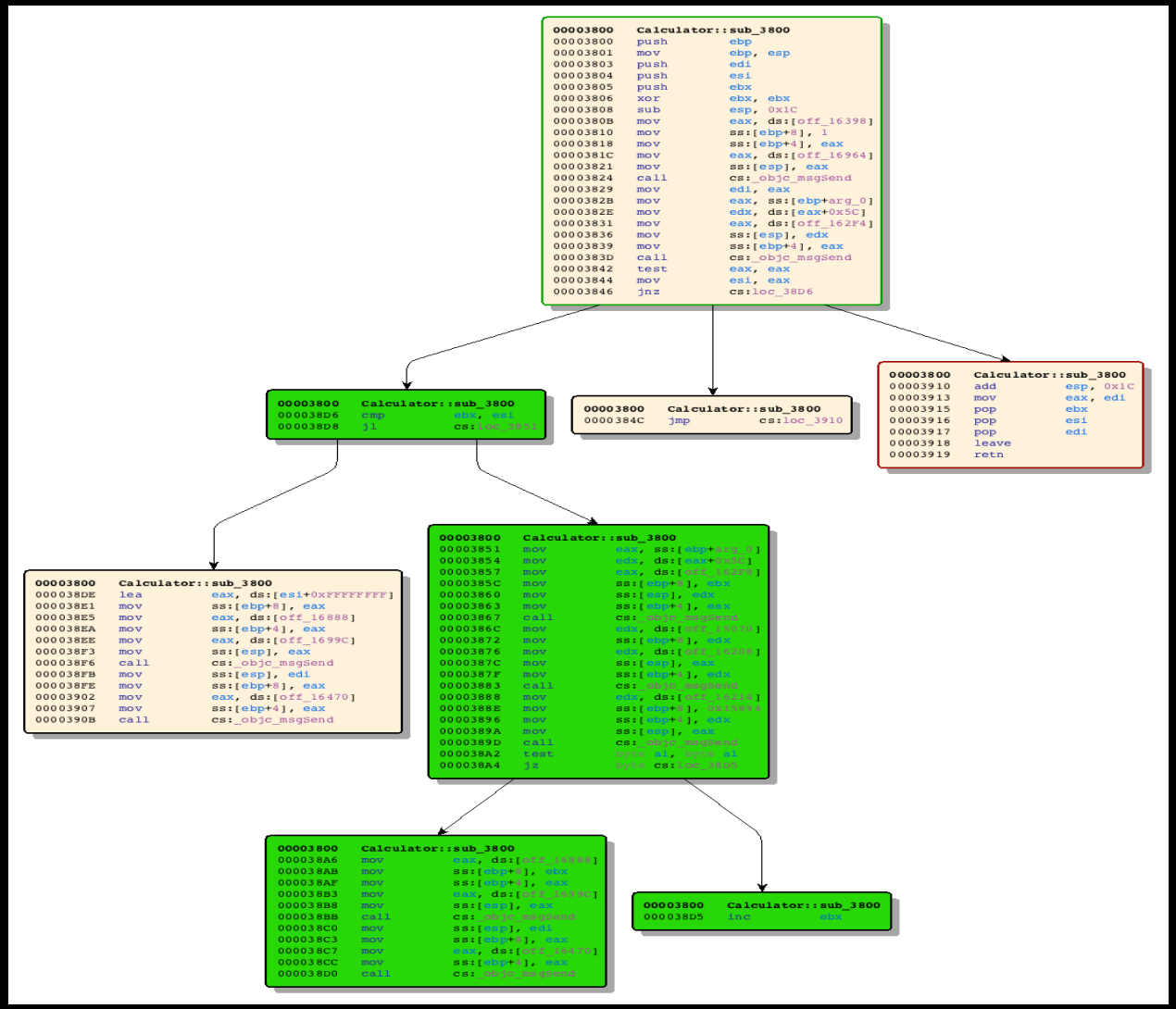
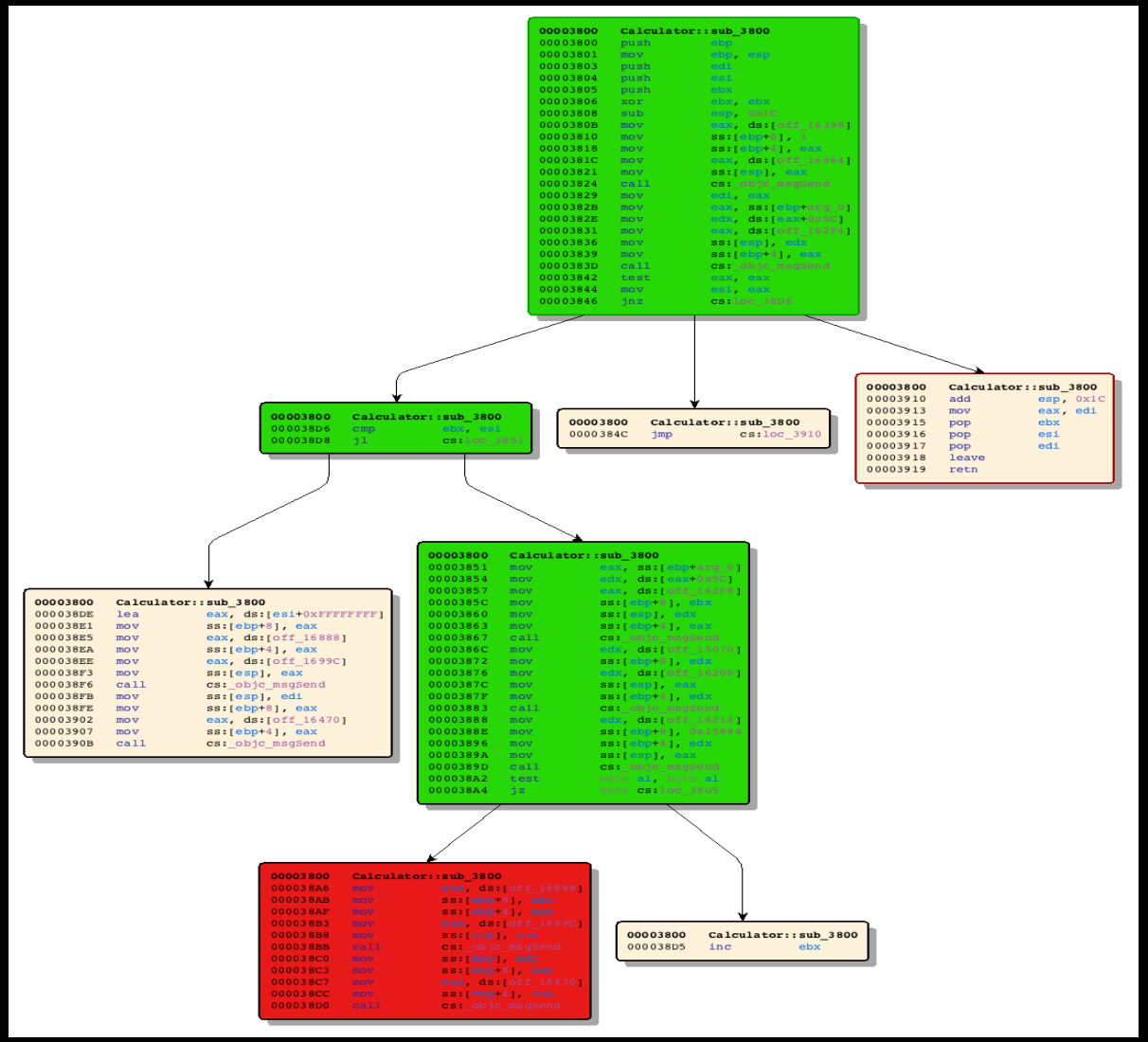
00003800 push ebp
00003801 mov ebp, esp
00003803 push edi
00003804 push esi
00003805 push ebx
00003806 xor ebx, ebx
00003808 sub esp, 0x1C
0000380B mov eax, ds:[off_16398]
00003810 mov ss:[ebp+8], 1
00003818 mov ss:[ebp+4], eax
0000381C mov eax, ds:[off_16964]
00003821 mov ss:[esp], eax
00003824 call cs:_objc_msgSend
00003829 mov edi, eax
0000382B mov eax, ss:[ebp+arg_0]
0000382E mov edx, ds:[eax+0x5C]
00003831 mov eax, ds:[off_162F4]
00003836 mov ss:[esp], edx
00003839 mov ss:[ebp+4], eax
0000383D call cs:_objc_msgSend
00003842 test eax, eax
00003844 mov esi, eax
00003846 jnz cs:loc_38D6
00003800 Calculator::sub_3800
000038D6 cmp ebx, esi
000038D8 jl cs:loc_3851
00003800 Calculator::sub_3800
0000384C jmp cs:loc_3910
00003800 Calculator::sub_3800
000038DE lea eax, ds:[esi+0xFFFFFFFF]
000038E1 mov ss:[ebp+8], eax
000038E5 mov eax, ds:[off_16888]
000038EA mov ss:[ebp+4], eax
000038EE mov eax, ds:[off_1699C]
000038F3 mov ss:[esp], eax
000038F6 call cs:_objc_msgSend
000038FB mov ss:[esp], edi
000038FE mov ss:[ebp+8], eax
00003902 mov eax, ds:[off_16470]
00003907 mov ss:[ebp+4], eax
0000390B call cs:_objc_msgSend
00003800 Calculator::sub_3800
00003851 mov eax, ss:[ebp+arg_0]
00003854 mov edx, ds:[eax+0x5C]
00003857 mov eax, ds:[off_162F8]
0000385C mov ss:[esp+4], edx
00003860 mov ss:[esp], eax
00003863 mov ss:[ebp+4], ebx
00003867 call cs:_objc_msgSend
0000386C mov eax, ds:[off_15070]
00003872 mov ss:[esp+4], eax
00003876 mov eax, ds:[off_16208]
0000387C mov ss:[esp], eax
0000387F mov ss:[ebp+4], edx
00003883 call cs:_objc_msgSend
00003888 mov edx, ds:[off_16214]
0000388E mov ss:[ebp+4], 0x15894
00003896 mov ss:[ebp+4], edx
0000389A mov ss:[ebp], eax
0000389D call cs:_objc_msgSend
000038A2 test al, byte ptr [esi]
000038A4 jz byte cs:loc_38D5
00003800 Calculator::sub_3800
000038A6 mov eax, ds:[off_16888]
000038AB mov ss:[ebp+8], eax
000038AF mov ss:[ebp+4], edi
000038B3 mov eax, ds:[off_1699C]
000038B8 mov ss:[esp], eax
000038BB call cs:_objc_msgSend
000038C0 mov ss:[esp], edi
000038C3 mov ss:[ebp+8], eax
000038C7 mov eax, ds:[off_16470]
000038CC mov ss:[ebp+4], eax
000038D0 call cs:_objc_msgSend
00003800 Calculator::sub_3800
000038D5 inc ebx
00003800 Calculator::sub_3800
00003910 add esp, 0x1C
00003913 mov eax, edi
00003915 pop ebx
00003916 pop esi
00003917 pop edi
00003918 leave
00003919 retn

Dominator tree



Dominators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00003800 push ebp
00003801 mov ebp, esp
00003803 push edi
00003804 push esi
00003805 push ebx
00003806 xor ebx, ebx
00003808 sub esp, 0x1C
0000380B mov eax, ds:[off_16388]
00003810 mov ss:[ebp+var_C], 1
00003818 mov ss:[ebp+var_8], eax
0000381C mov eax, ds:[off_16384]
00003821 mov ss:[esp], eax
00003824 call cs:_objc_msgSend
00003829 mov edi, eax
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0000382E mov edx, ds:[eax+0x5C]
00003831 mov eax, ds:[off_16284]
00003836 mov ss:[esp], edx
00003839 mov ss:[ebp+4], eax
0000383D call cs:_objc_msgSend
00003842 test eax, eax
00003844 mov esi, eax
00003846 jnz cs:loc_3854
00003800 Calculator::sub_3800
000038D6 cmp ebx, esi
000038D8 jl cs:loc_3854
00003800 Calculator::sub_3800
0000384C jmp cs:loc_3910
00003800 Calculator::sub_3800
00003910 add esp, 0x1C
00003913 mov eax, edi
00003915 pop ebx
00003916 pop esi
00003917 pop edi
00003918 leave
00003919 retn
00003800 Calculator::sub_3800
000038DE lea eax, ds:[esi+0xFFFFFFFF]
000038E1 mov ss:[ebp+8], eax
000038E5 mov eax, ds:[off_16888]
000038EA mov ss:[ebp+4], eax
000038EE mov eax, ds:[off_1699C]
000038F3 mov ss:[esp], eax
000038F6 call cs:_objc_msgSend
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0000385C mov ss:[ebp+8], ebx
00003860 mov ss:[esp], edx
00003863 mov ss:[ebp+4], eax
00003867 call cs:_objc_msgSend
0000386C mov edx, ds:[off_16000]
00003872 mov ss:[ebp+4], edx
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00003883 call cs:_objc_msgSend
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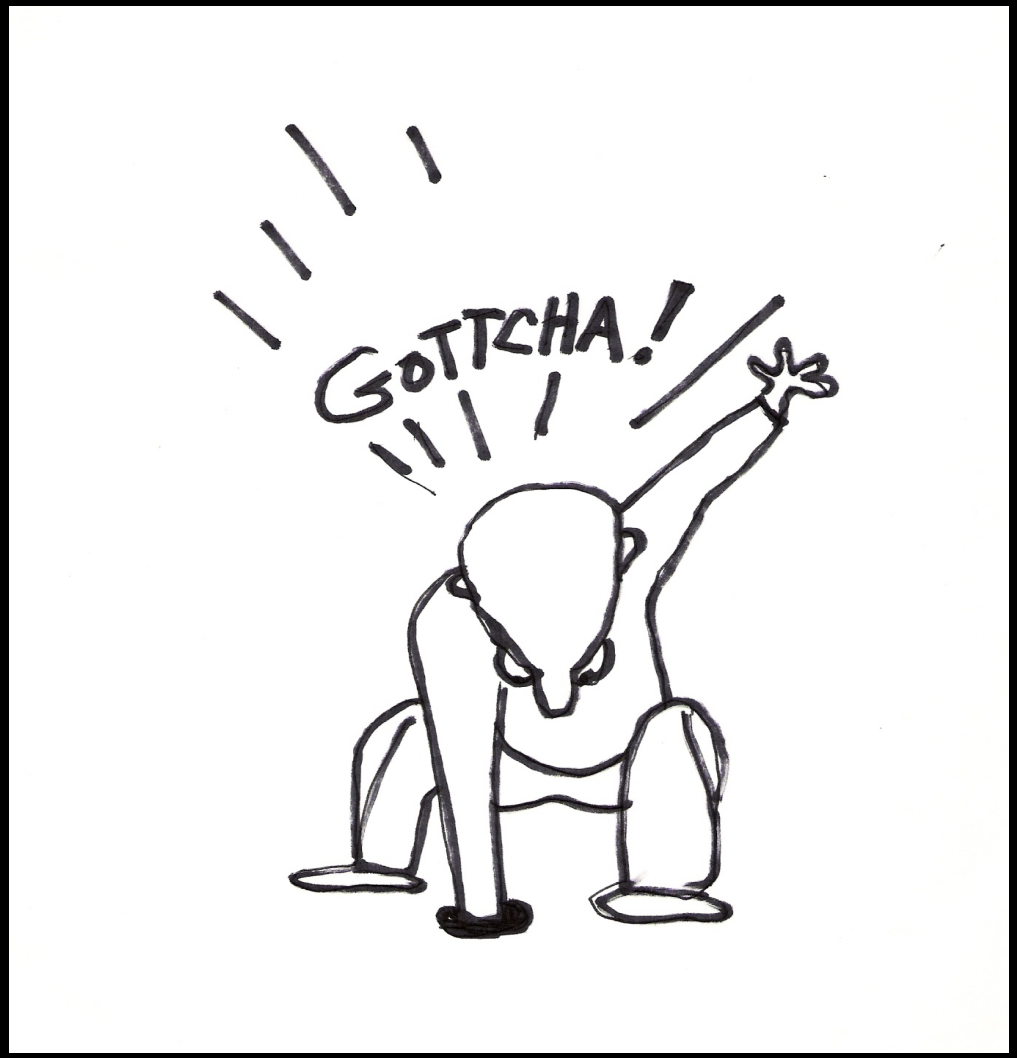
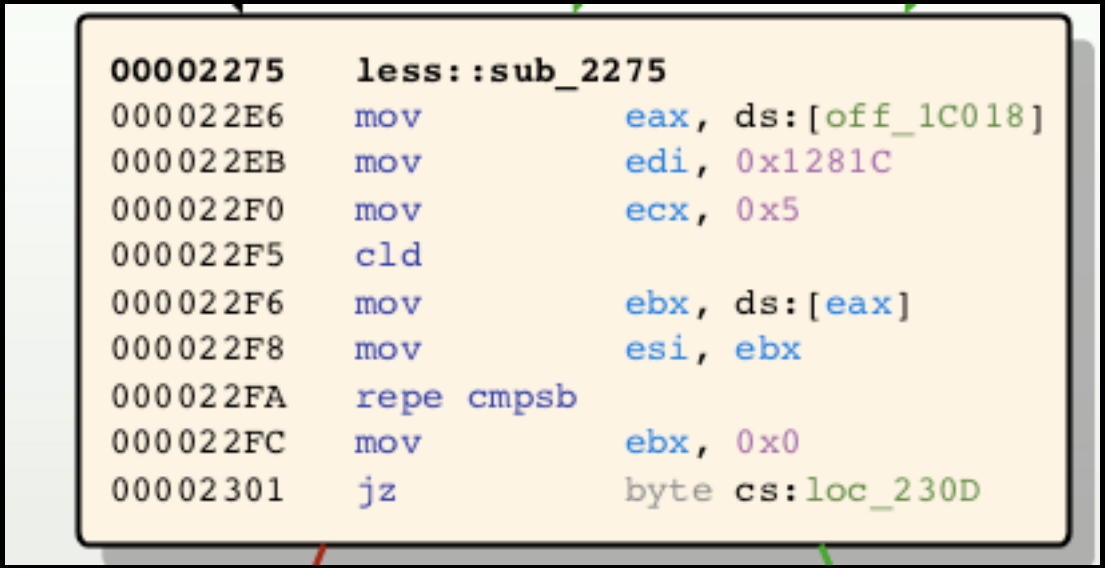
0000388E mov ss:[ebp+8], 0x15444
00003896 mov ss:[ebp+4], edx
0000389A mov ss:[esp], eax
0000389D call cs:_objc_msgSend
000038A2 test al, 0x80, al
000038A4 jz cs:loc_3800
00003800 Calculator::sub_3800
000038A6 mov eax, ds:[off_16888]
000038AB mov ss:[ebp+4], eax
000038AF mov ss:[ebp+8], eax
000038B3 mov eax, ds:[off_1699C]
000038B8 mov ss:[esp], eax
000038BB call cs:_objc_msgSend
000038C0 mov ss:[esp], edi
000038C3 mov ss:[ebp+4], eax
000038C7 mov eax, ds:[off_16470]
000038CC mov ss:[ebp+8], eax
000038D0 call cs:_objc_msgSend
00003800 Calculator::sub_3800
000038D5 inc ebx

Implicit loops

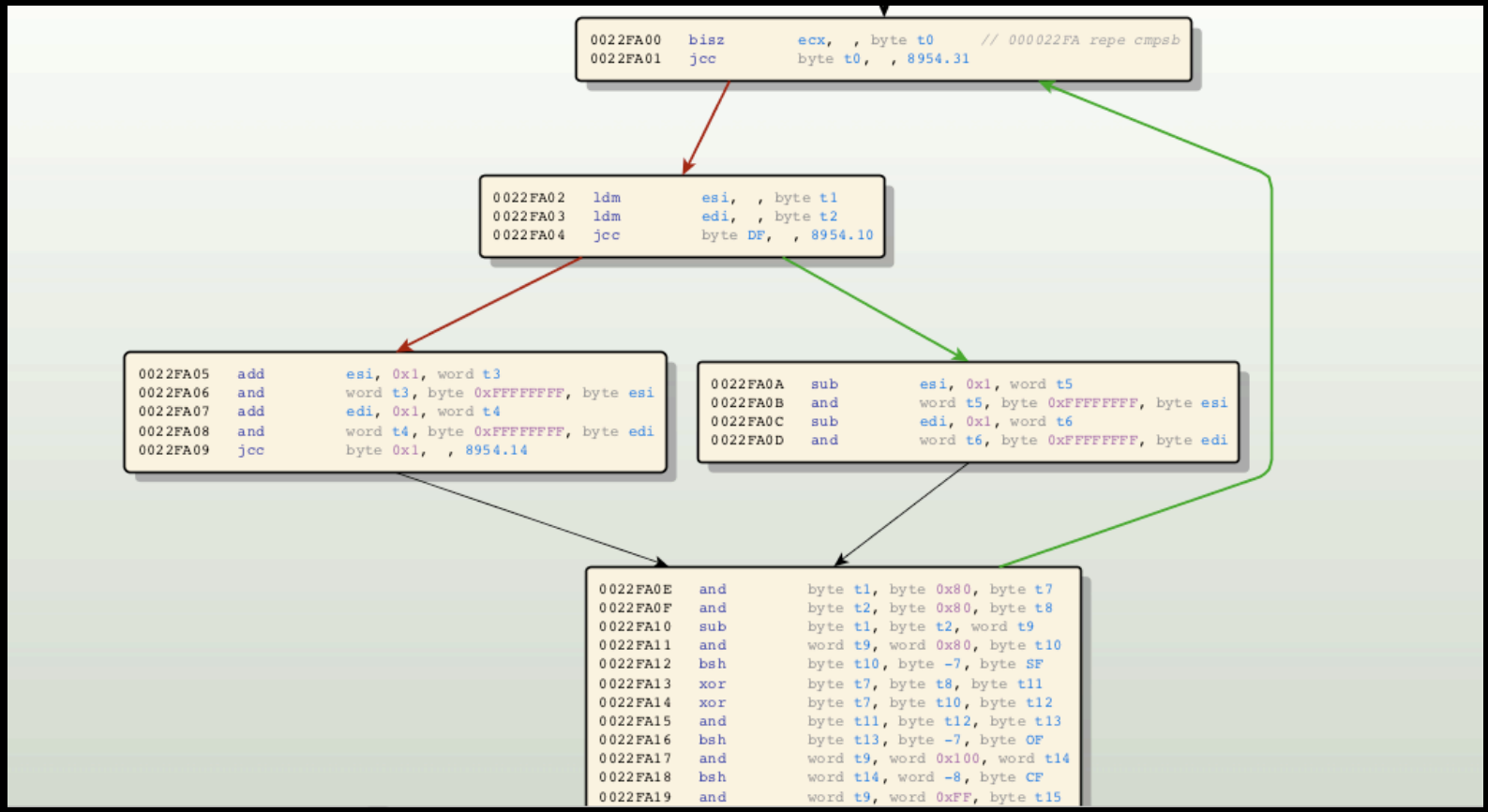
REIL



This one…


00002275 less::sub_2275
000022E6 mov eax, ds:[off_1C018]
000022EB mov edi, 0x1281C
000022F0 mov ecx, 0x5
000022F5 cld
000022F6 mov ebx, ds:[eax]
000022F8 mov esi, ebx
000022FA repe cmpsb
000022FC mov ebx, 0x0
00002301 jz byte cs:loc_230D

…to this one


0022FA00 bisz ecx, , byte t0 // 000022FA repe cmpsb
0022FA01 jcc byte t0, , 8954.31
0022FA02 ldm esi, , byte t1
0022FA03 ldm edi, , byte t2
0022FA04 jcc byte DF, , 8954.10
0022FA05 add esi, 0x1, word t3
0022FA06 and word t3, byte 0xFFFFFFFF, byte esi
0022FA07 add edi, 0x1, word t4
0022FA08 and word t4, byte 0xFFFFFFFF, byte edi
0022FA09 jcc byte 0x1, , 8954.14
0022FA0A sub esi, 0x1, word t5
0022FA0B and word t5, byte 0xFFFFFFFF, byte esi
0022FA0C sub edi, 0x1, word t6
0022FA0D and word t6, byte 0xFFFFFFFF, byte edi
0022FA0E and byte t1, byte 0x80, byte t7
0022FA0F and byte t2, byte 0x80, byte t8
0022FA10 sub byte t1, byte t2, word t9
0022FA11 and word t9, word 0x80, byte t10
0022FA12 bsh byte t10, byte -7, byte SF
0022FA13 xor byte t7, byte t8, byte t11
0022FA14 xor byte t7, byte t10, byte t12
0022FA15 and byte t11, byte t12, byte t13
0022FA16 bsh byte t13, byte -7, byte OF
0022FA17 and word t9, word 0x100, word t14
0022FA18 bsh word t14, word -8, byte CF
0022FA19 and word t9, word 0xFF, byte t15

Is that enough?

Not enough

Of course not, more heuristics needed

```
void *safe_strcpy(void *old_dest, void
*src, int size){

   void *dst = realloc(old_dest, size +1);
   strncpy(dst, src, size);
   return dst;
}
```

Add your own

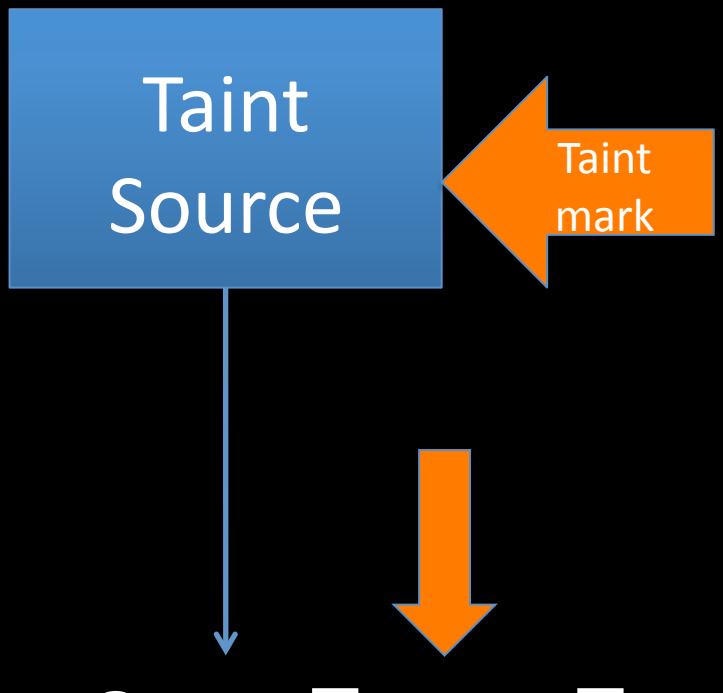
For static analysis we use

DEMO

Questions!

Data Tainting

Example



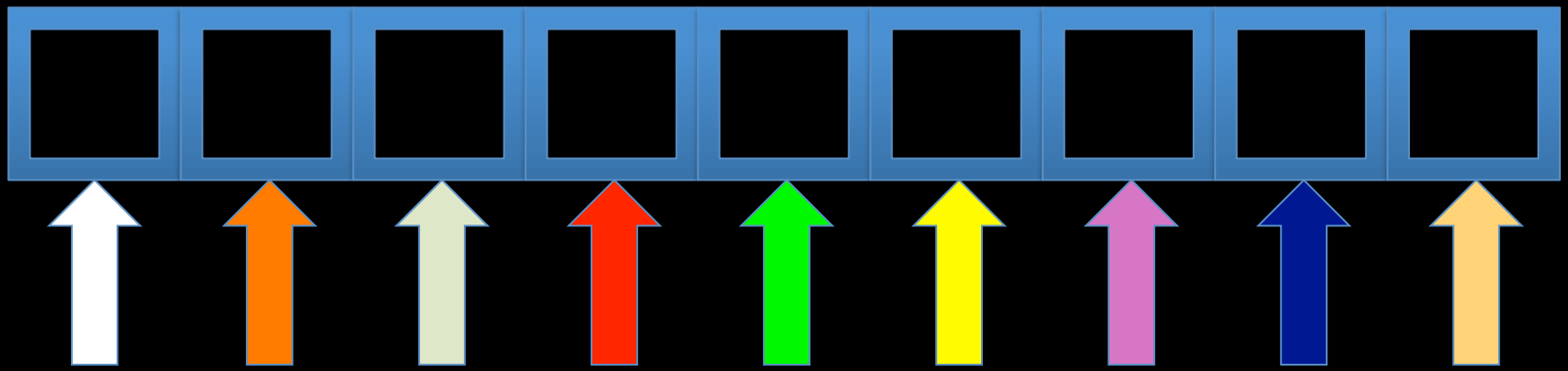

```
movl 0x4[eax], ebx
```

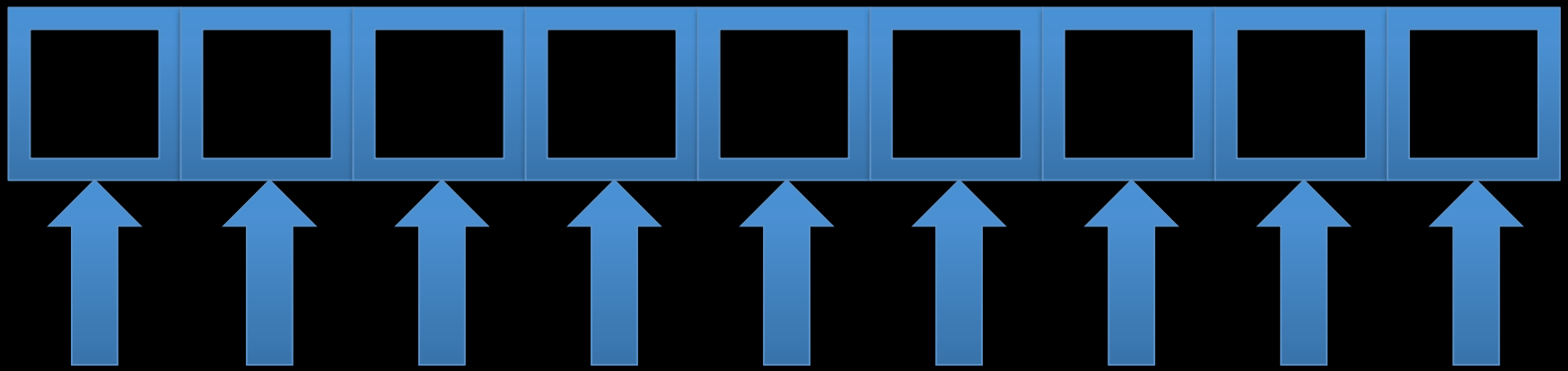
Dytan

PIN

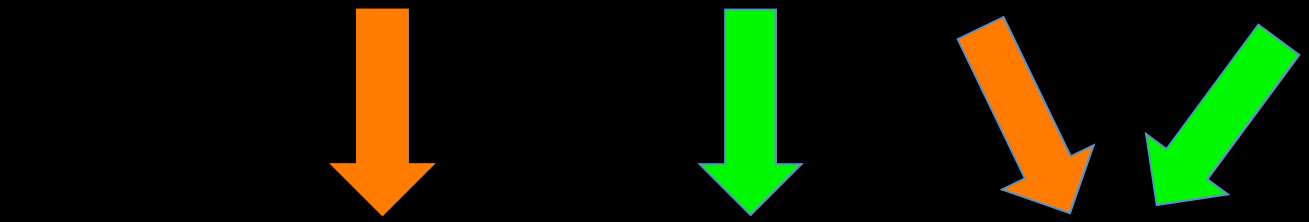
Taint sources

Markings granularity





Propagation



Output

Registers

Memory locations

DEMO

Questions!

In-memory fuzzing

Example

esi = 0x30f064 → Original loc

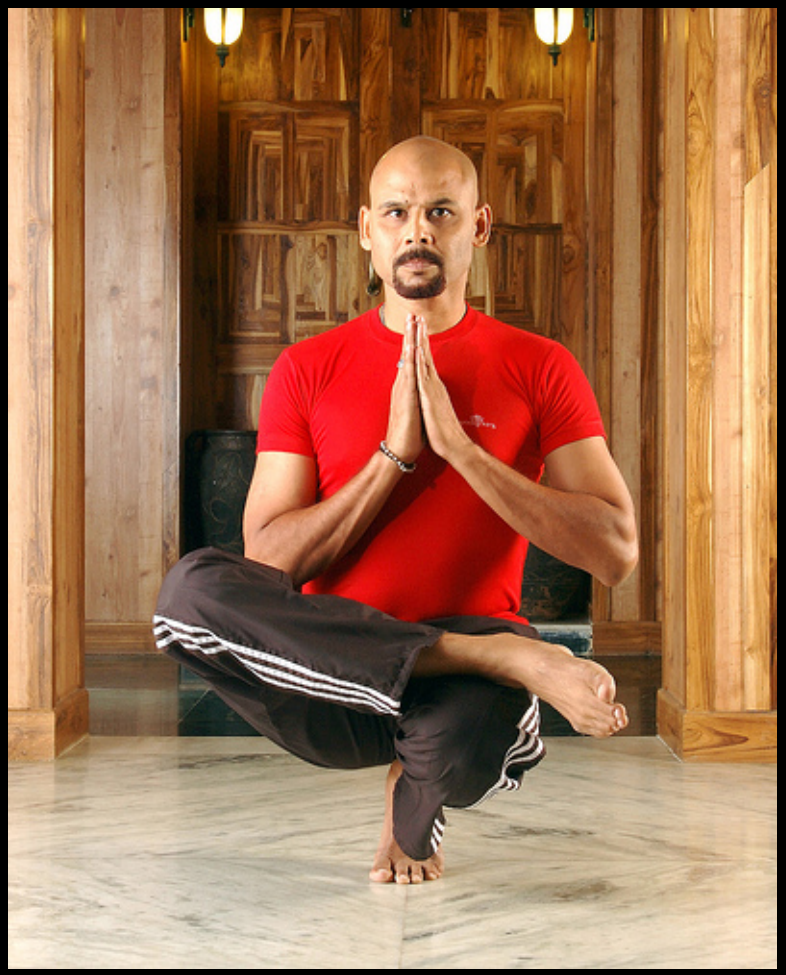
Fuzzed loc → esi = 0x30f0A4

```
rep movs
```

Why?

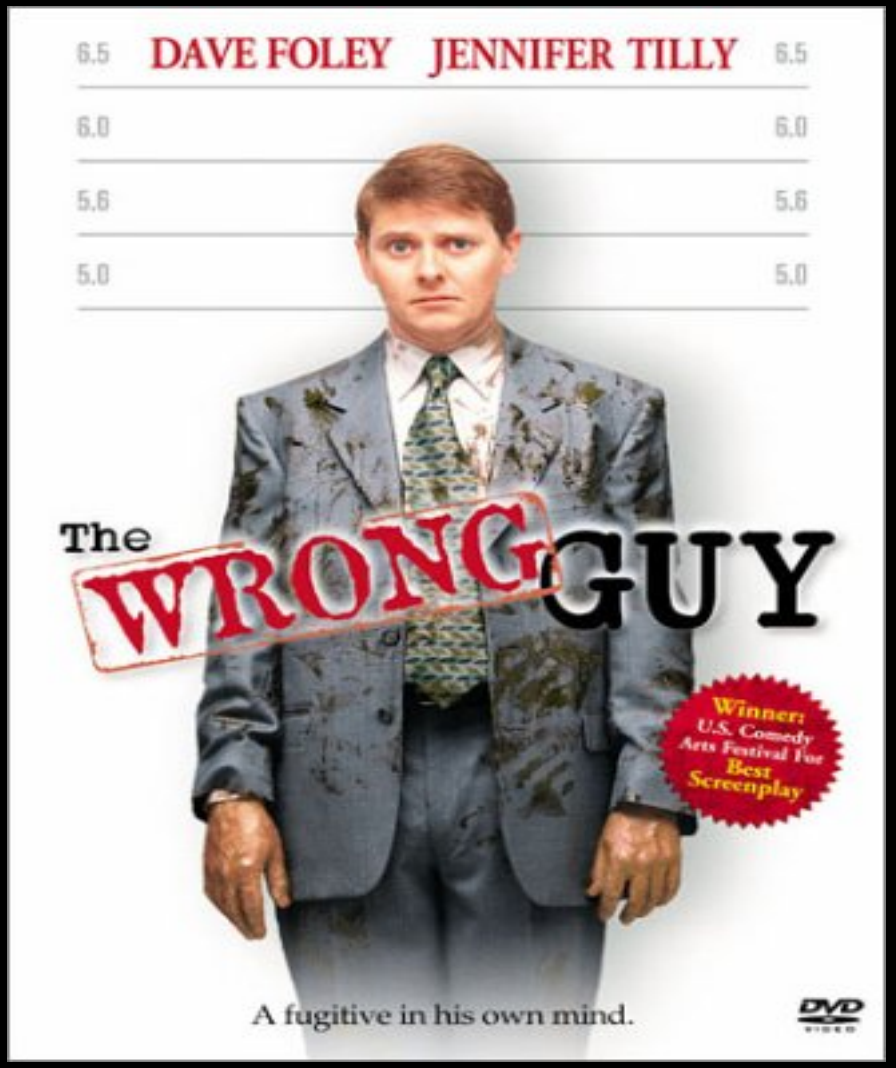
Problems

Expertise and patience



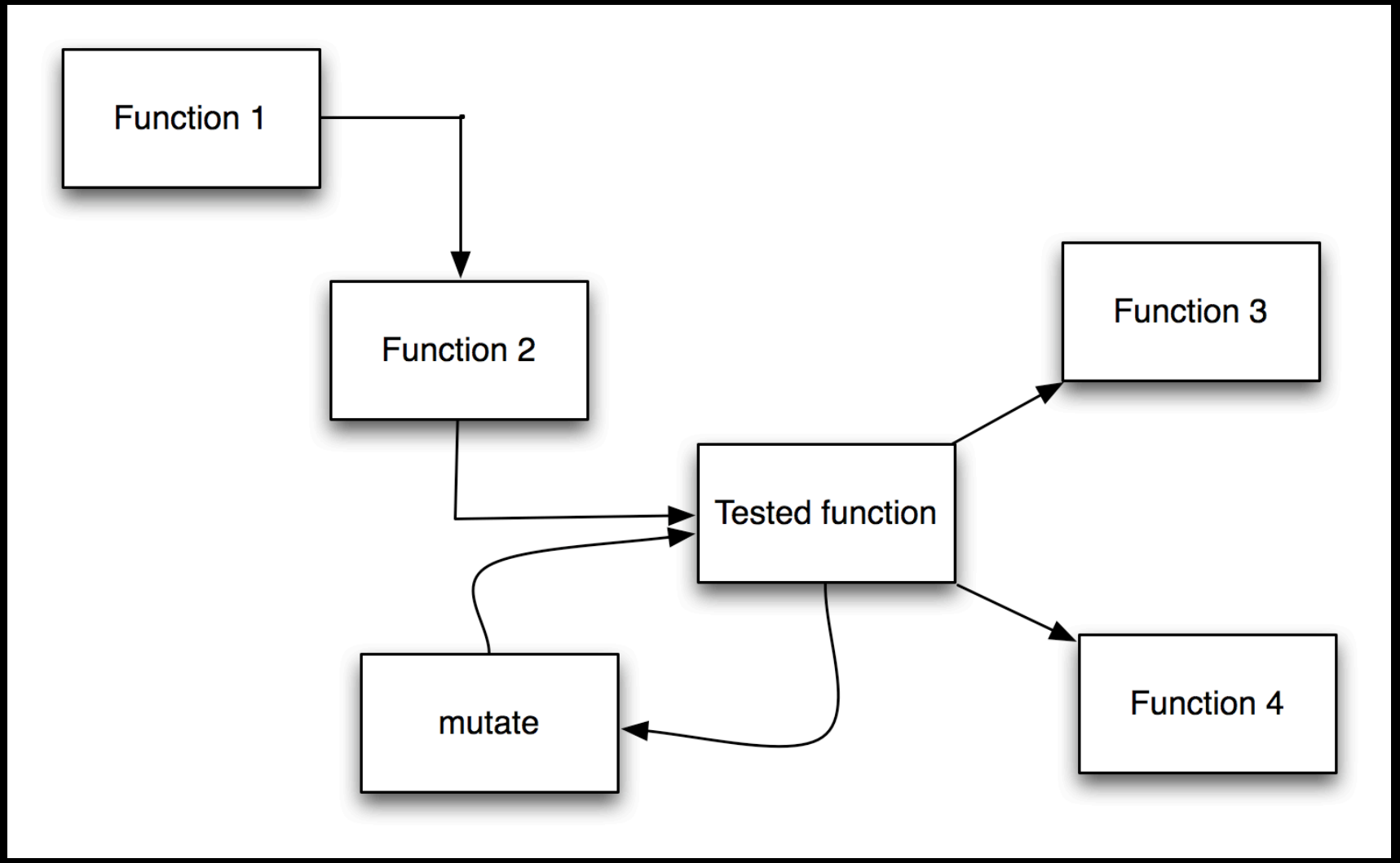
Memory instability

False positives

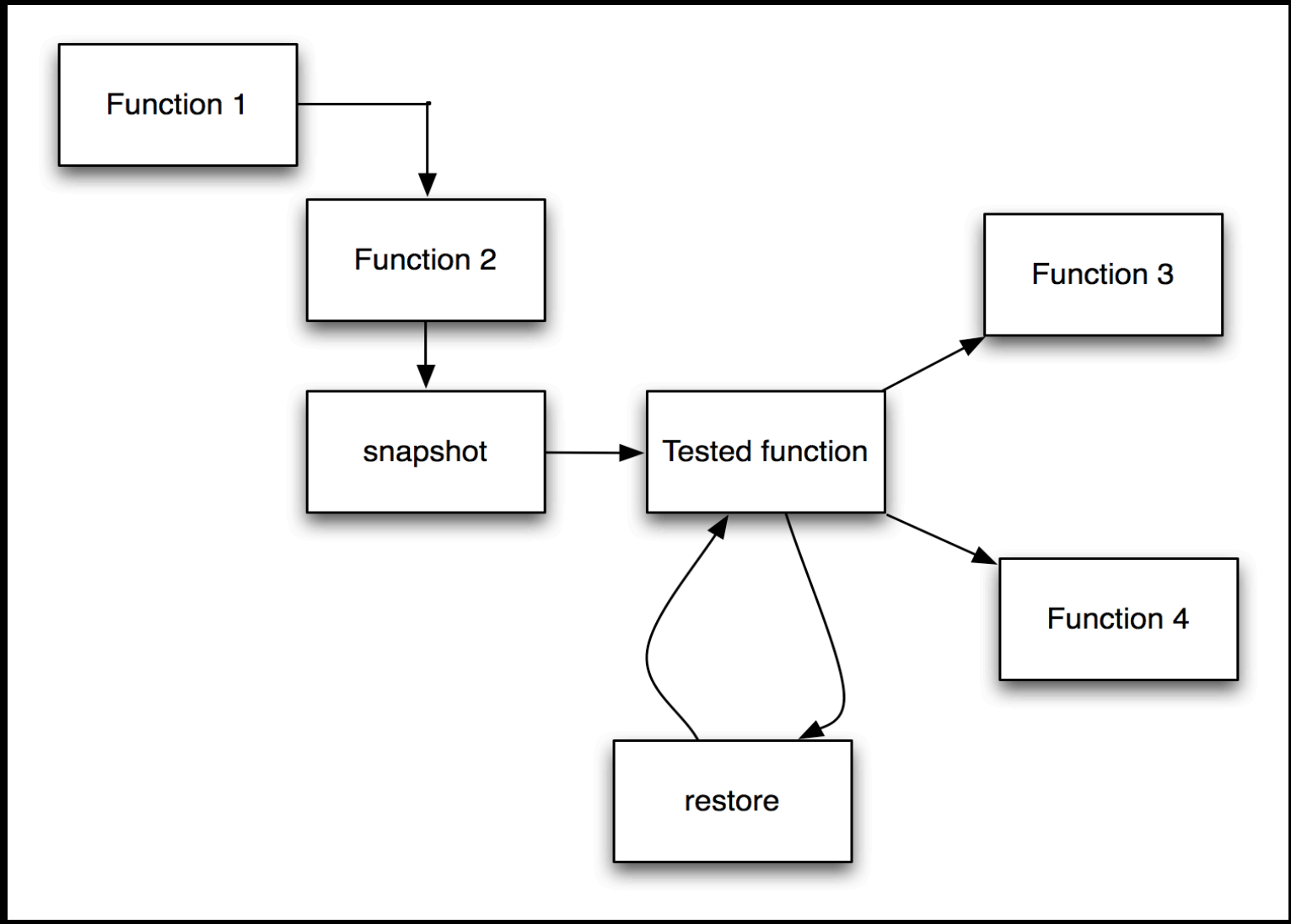


False negatives

Mutation loop insertion



Snapshot mutation restoration



What do we do?

- Hook image
- Hook functions
- Hook instructions

First approach

For instance…

30f064-30f068

ABCD 

0x8a Y 0x00
K

Second approach

Example

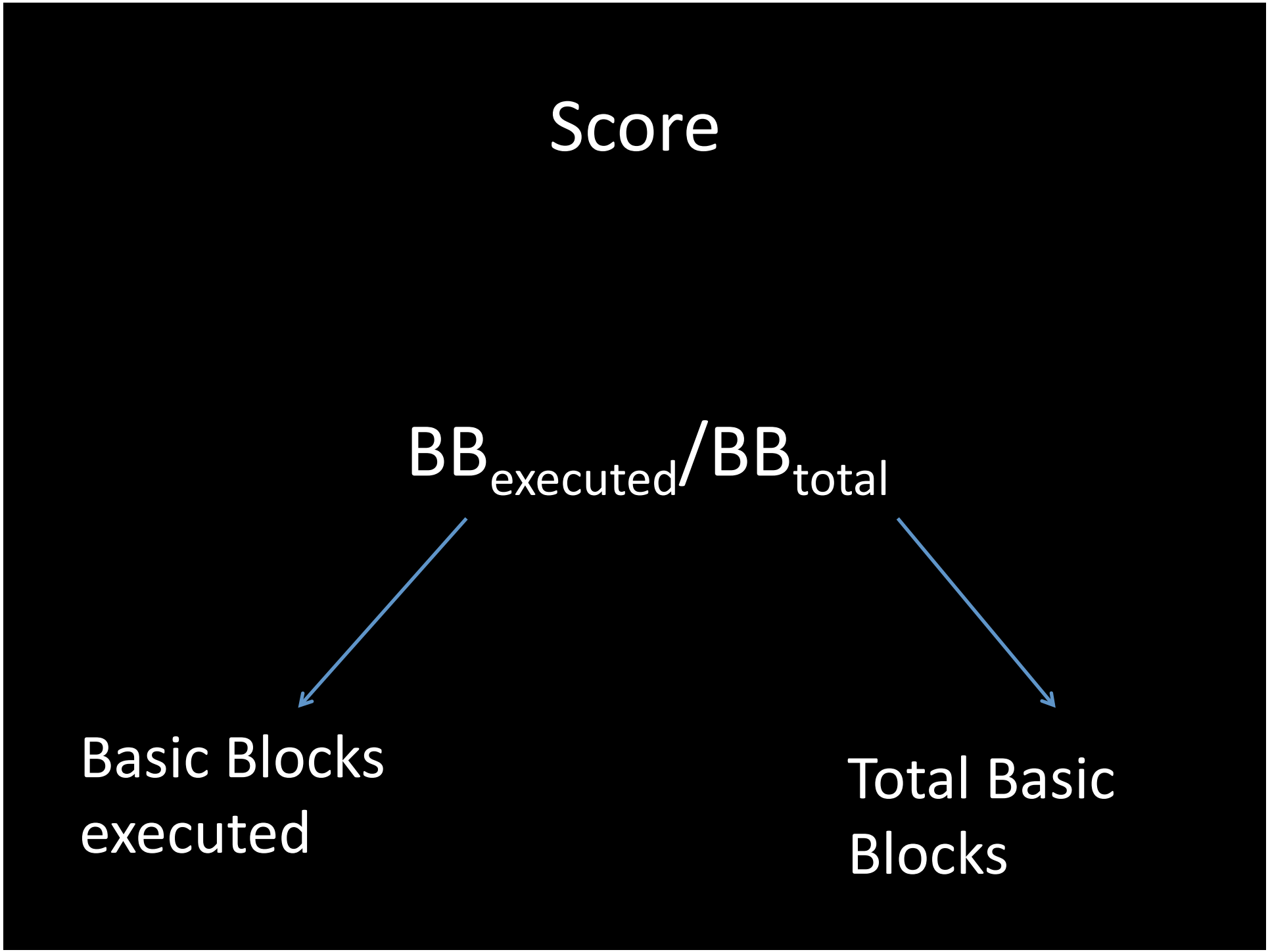
30f064-30f068

ABCD

30f084-30f098

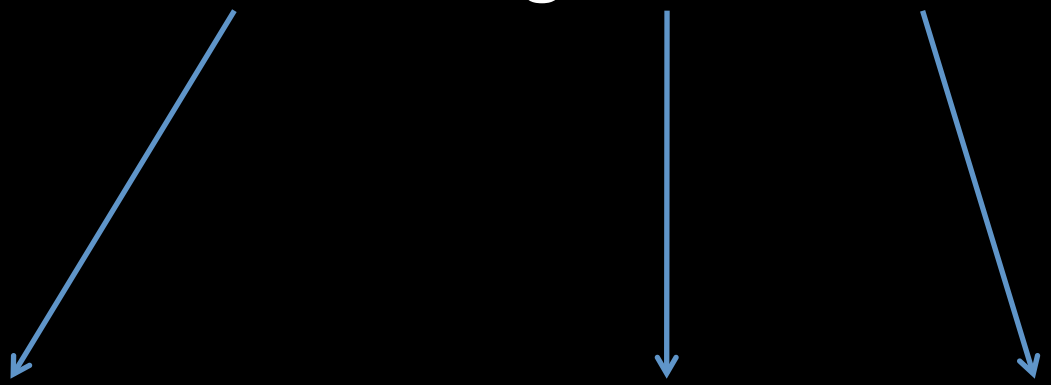
0x89 K D F 0x96
0x00 J K U Y W 0xA7
0xB8 0x00 0x10 A T N
0x00 0xD3

Code coverage


Score
$BB_{executed}/BB_{total}$
Basic Blocks executed
Total Basic Blocks

Halting

$$C_{evil} = C_{good} + t$$

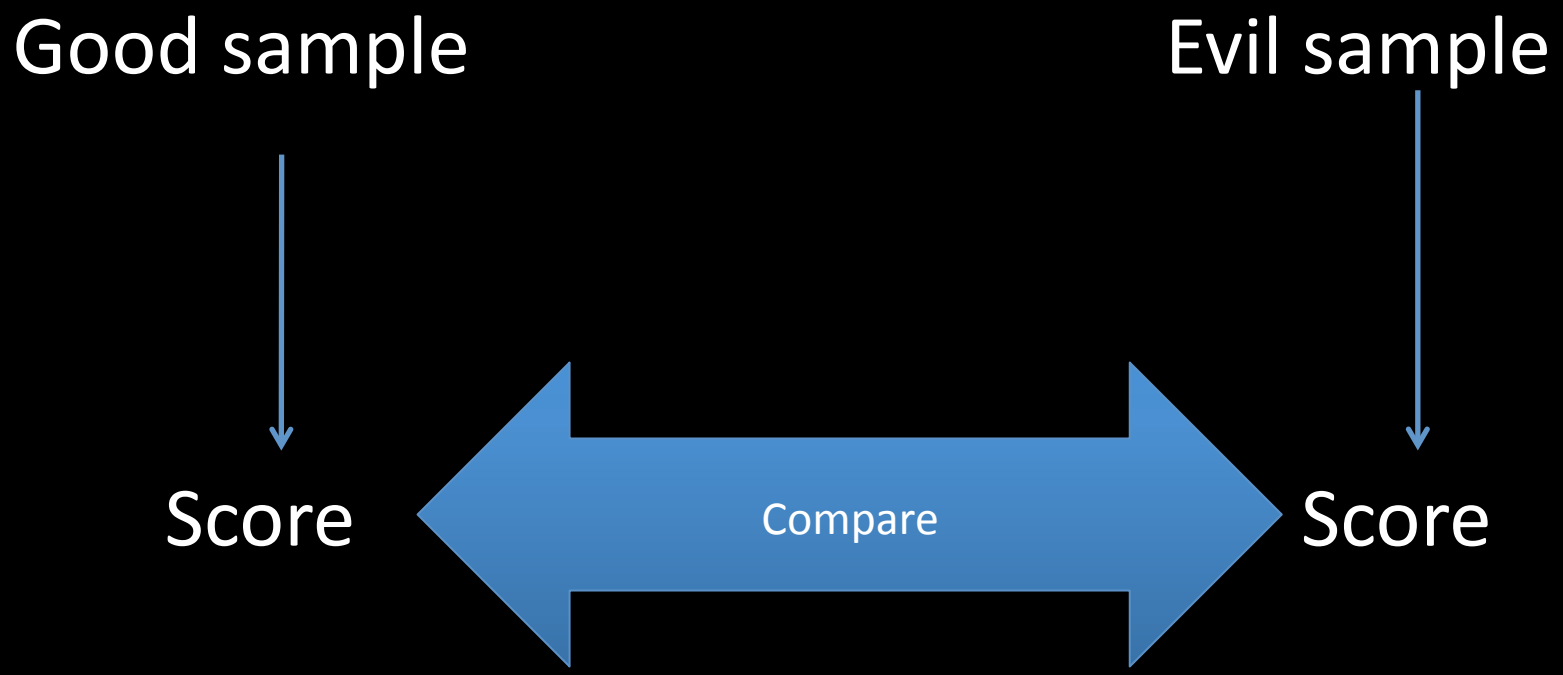


Code coverage evil sample

Code coverage good sample

User-supplied threshold

How?



What do we use?

Code coverage

Faults monitor

DEMO

Future – A reasoner

Thanks




Questions!

More Info

viozzo.wordpress.com

@_snagg

vincenzo.iozzo@zynamics.com