Rebootless kernel updates

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What is Ksplice?

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Running kernel with bug

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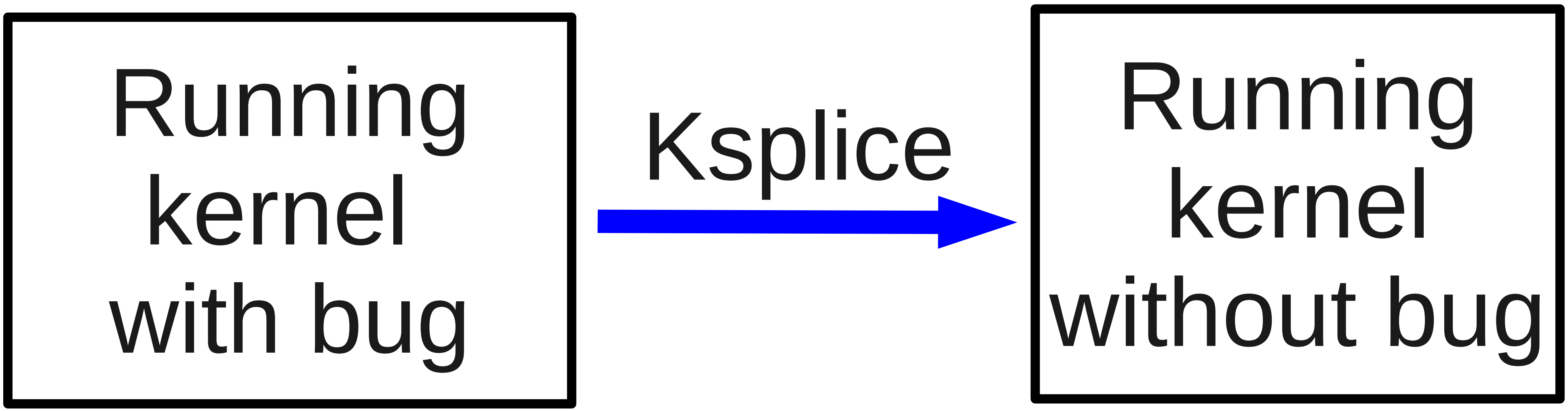

Update the kernel without disruption

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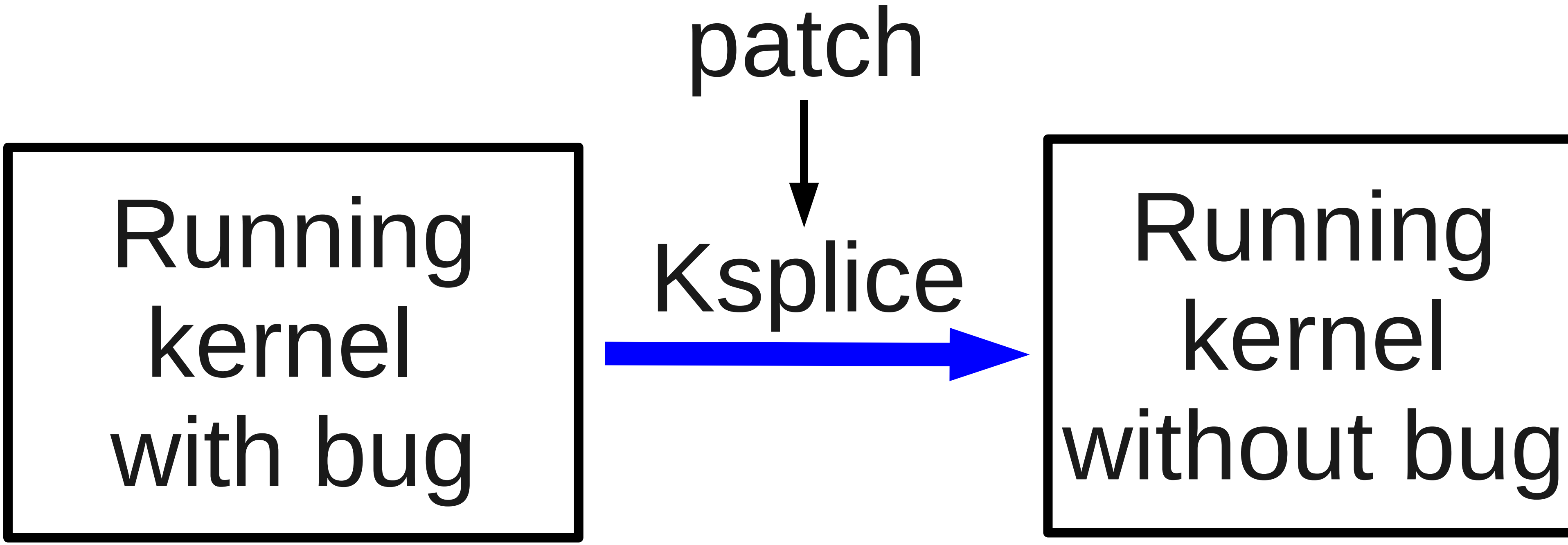

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- Get the benefits of patching...
  - Security improvements
  - Reliability improvements
- ... without the disruption of rebooting

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- Debugging/instrumentation

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- Lose software state
- Reboots can cause unexpected problems

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- New privilege escalation CVE every month
- > 90% of attacks exploit known vulnerabilities

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- So far: x86-32, x86-64, ARM

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- Tools in Debian sid, Ubuntu Jaunty, Fedora 8-10
- Proposed for mainline
- 5 engineers working on Ksplice full-time

CVE-2008-0600

fs/splice.c:

```
  if (unlikely(!len))
          break;
  error = -EFAULT;
- if (unlikely(!base))
+ if (!access_ok(VERIFY_READ, base, len))
          break;

  /*
```

```
$ ksplice-create --patch=splice ~/src
```

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Update written to ksplice-8c4.tar.gz
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$ ksplice-create --patch=splice ~/src

Update written to ksplice-8c4.tar.gz

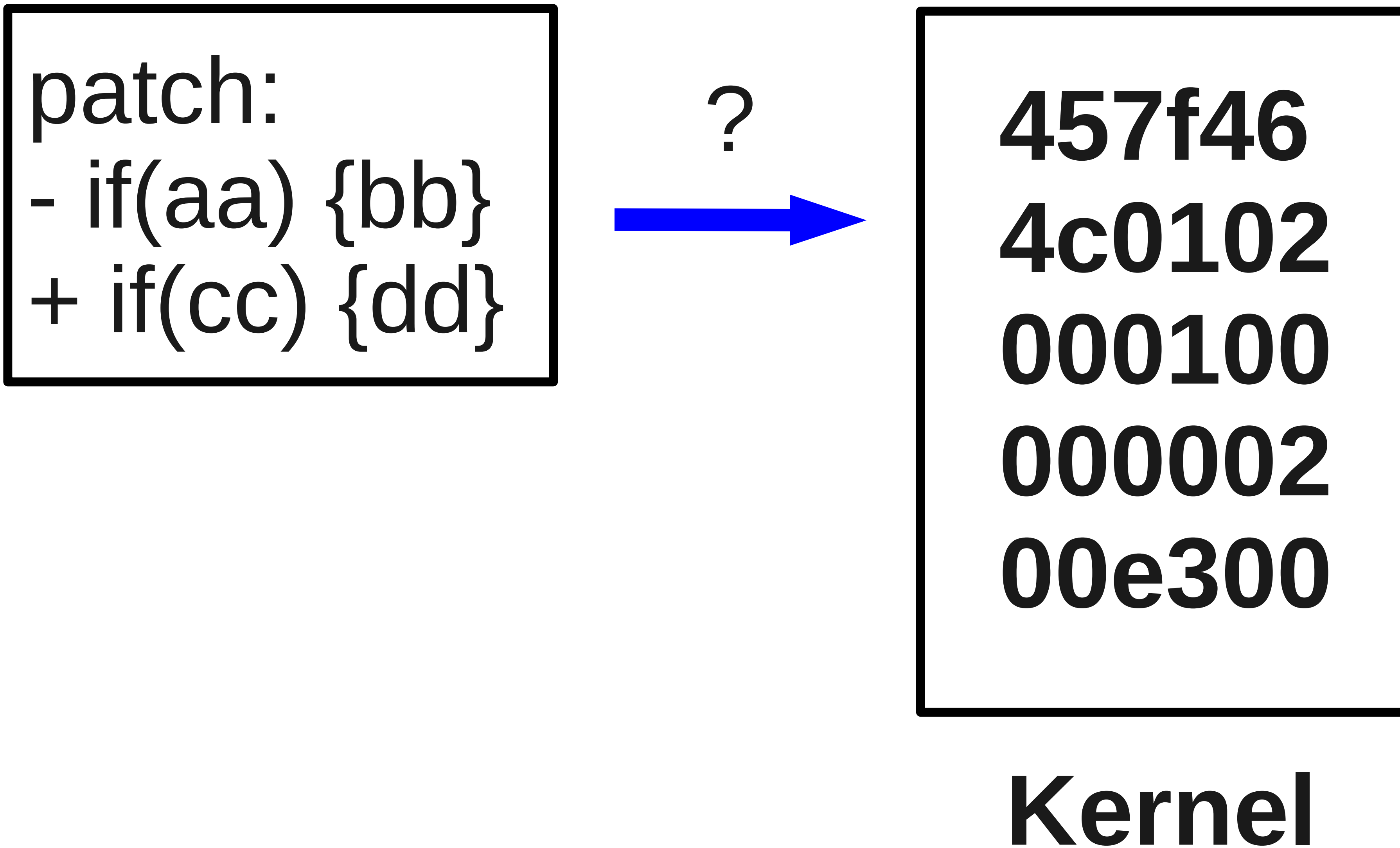
user then becomes the superuser

 # ksplice-apply ./ksplice-8c4.tar.gz

Done!

#

The Challenge



The rest of this talk

- How Ksplice works
- Evaluation: 2005-2008 CVEs
- Using Ksplice for debugging
- Demos
  - Protecting against x86 exploit
  - Debugging on Android
- Future plans

Design Outline

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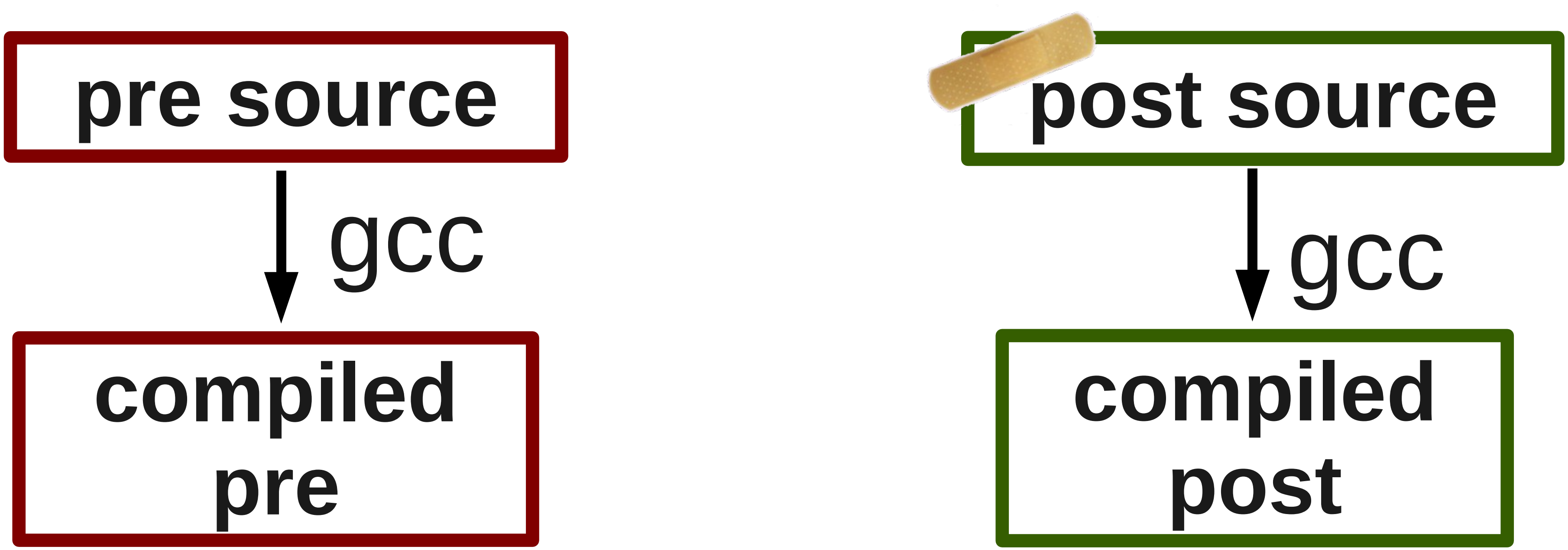
- Start redirecting execution to the replacement functions

pre-post differencing

pre source

post source

pre-post differencing



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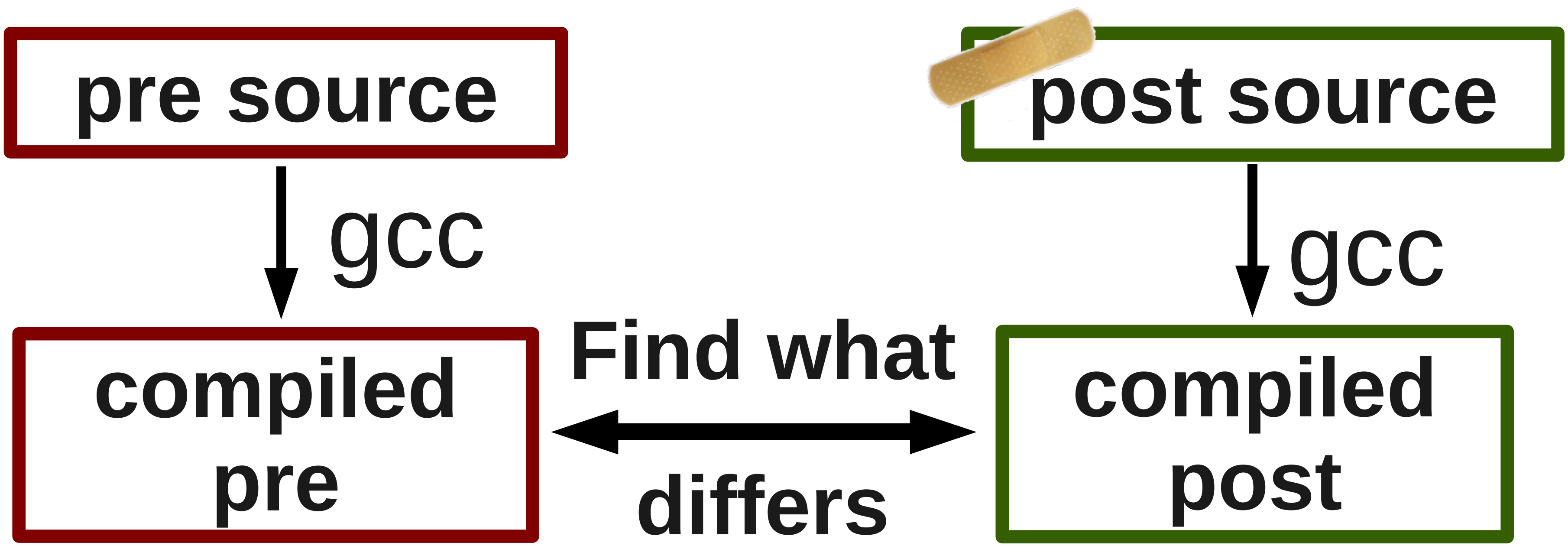

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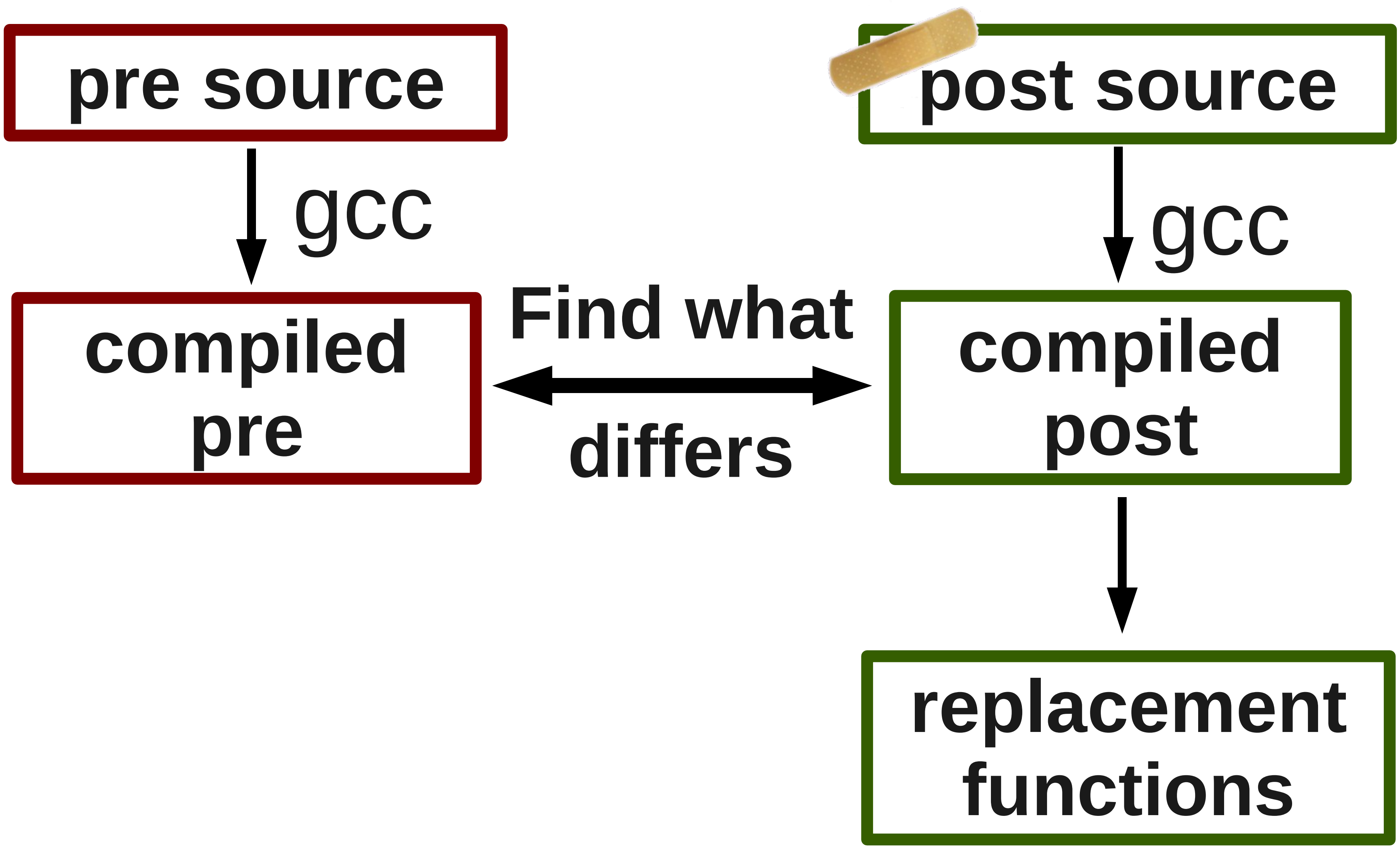
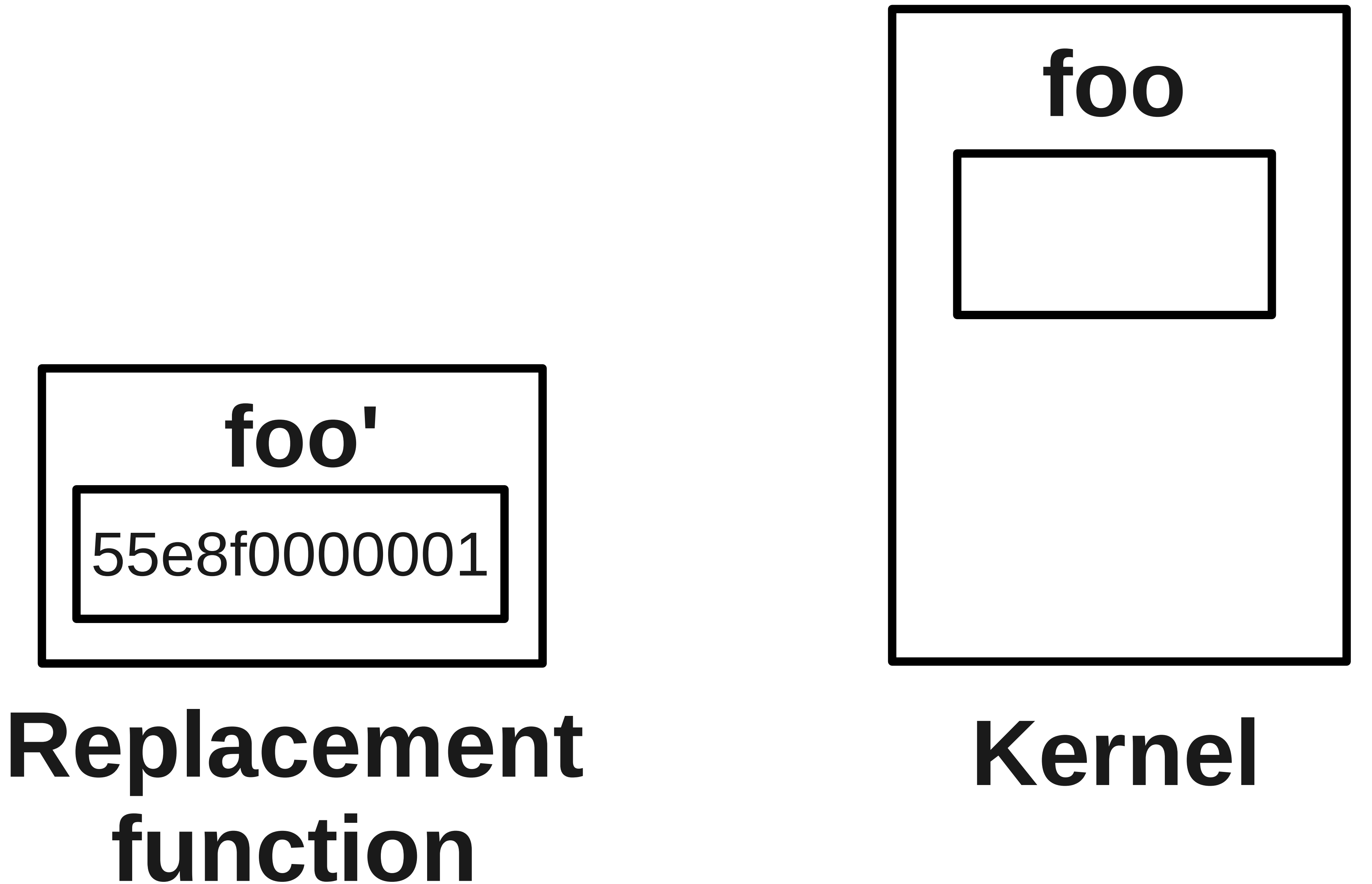


Redirect execution



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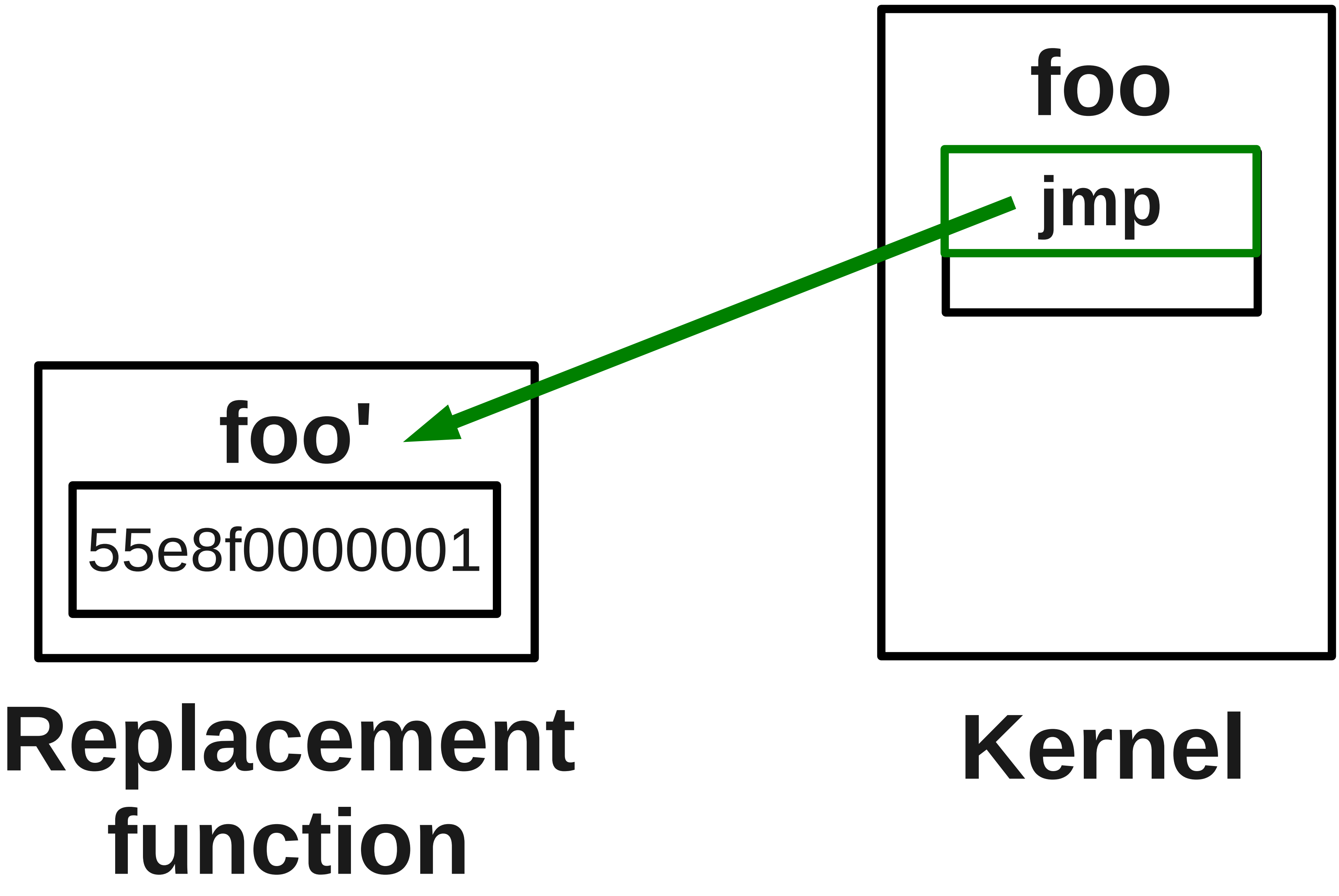
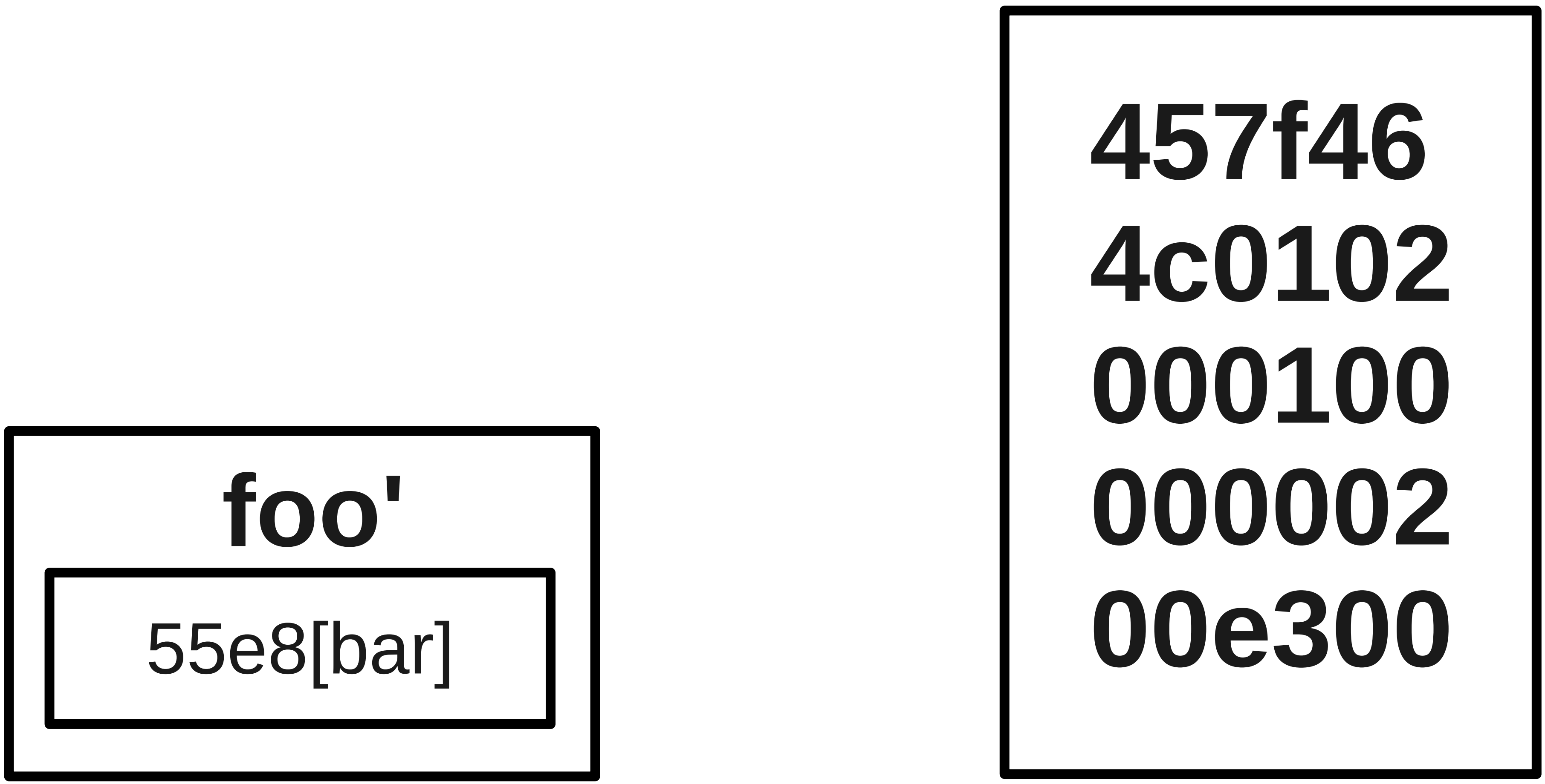


Handling symbolic references



Symbol table not sufficient

Matching pre code to running kernel

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- Byte-by-byte comparison

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- When pre code refers to symbol, discover symbol value based on running kernel

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- Byte-by-byte comparison
- When pre code refers to symbol, discover symbol value based on running kernel
- Discovered symbol values used to resolve symbols in replacement functions

replacement foo':

...

[bar]

...

replacement foo':
...
[bar]
...

Any pre function X from same scope:
...
[bar]
...

replacement foo':

...

[bar]

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Any pre function X from same scope:

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Kernel's running code:

replacement foo':
...
[bar]
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Kernel's running code:

[addr f0000000]
function X:
...
00 11 11 00
...

replacement foo':

...

[bar]

...

Any pre function X from same scope:

...

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bar = 00111100 + f0000002 - (-4)

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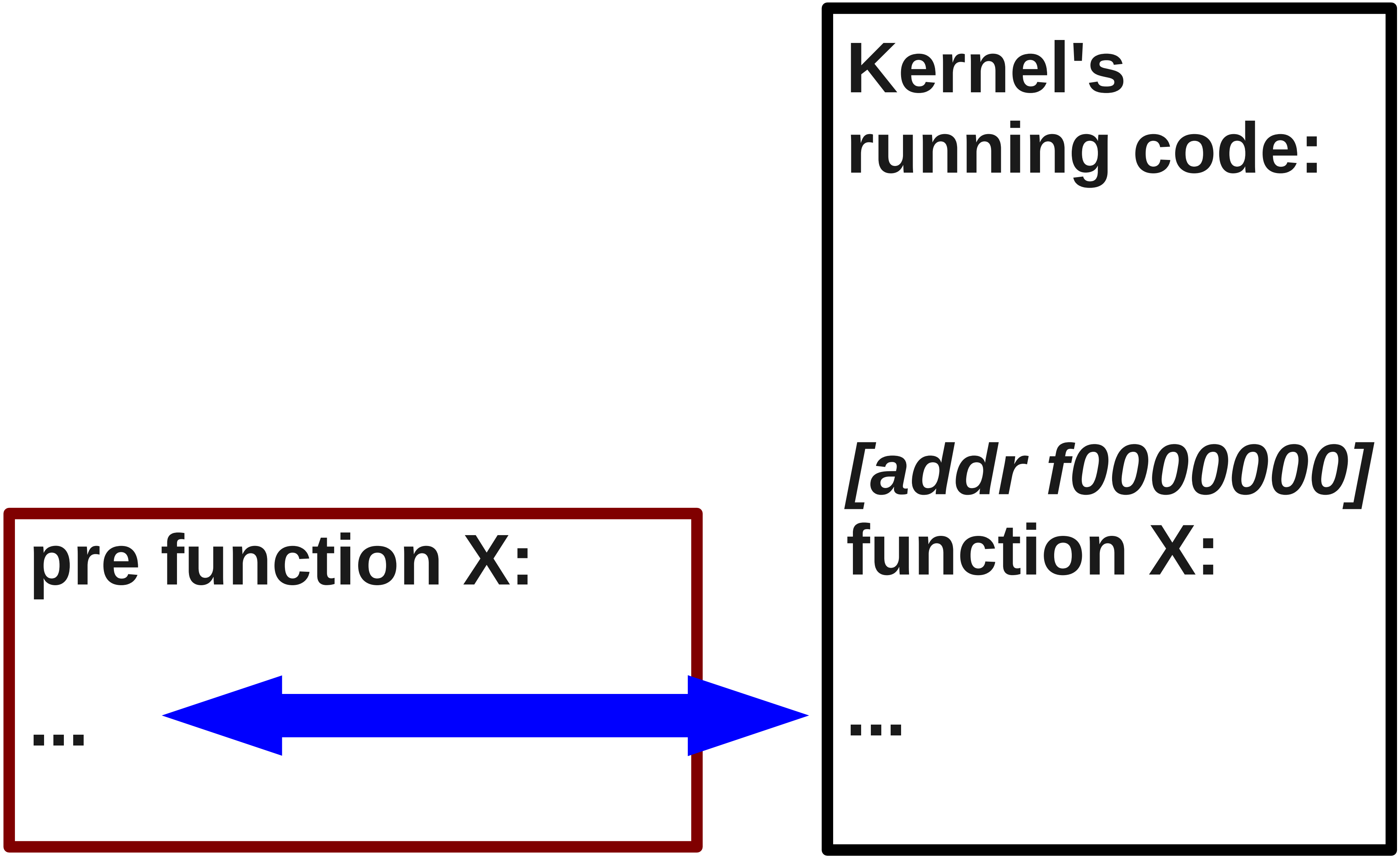
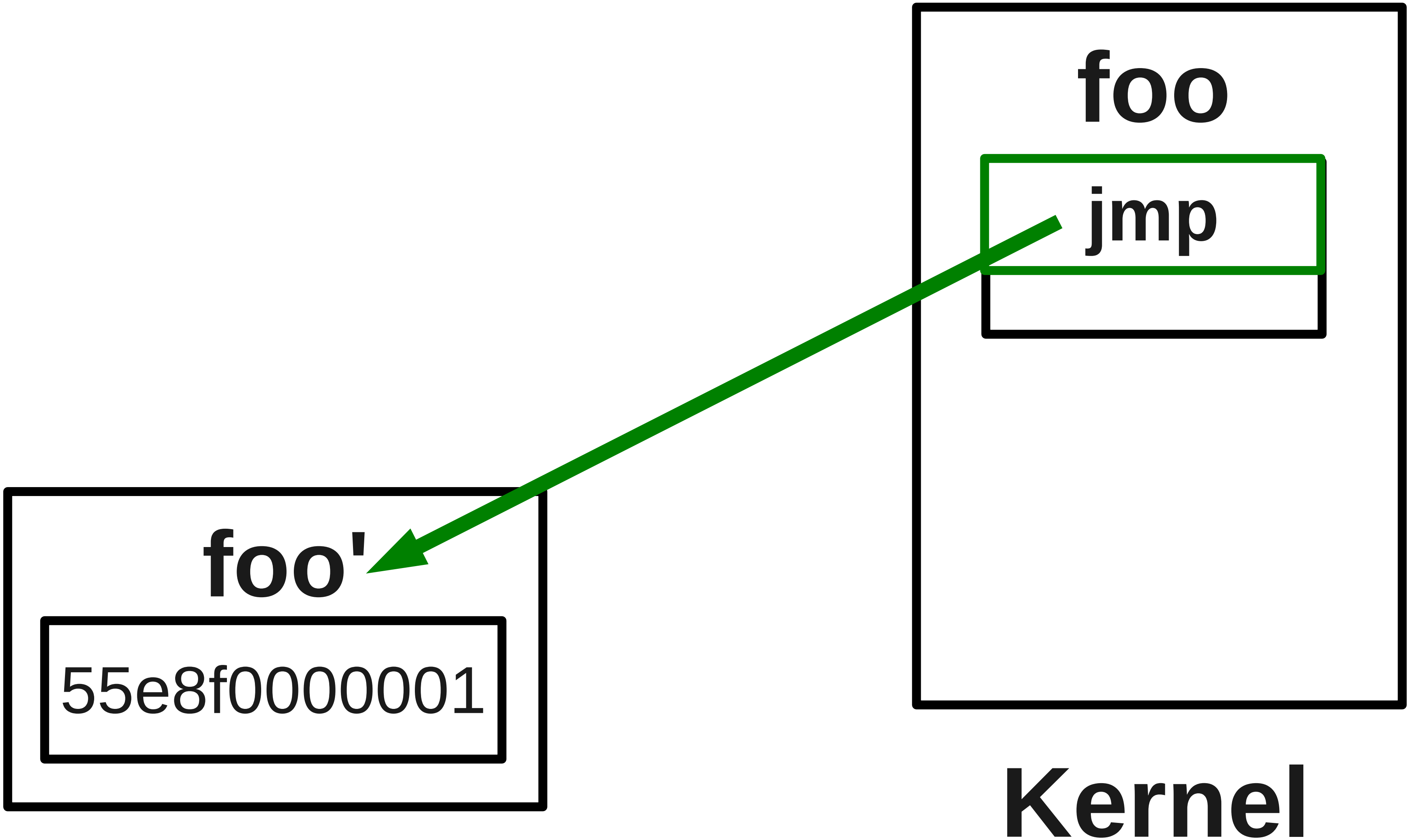
bar = 00111100 + f0000002 - (-4)
= f0111106



Also serves as extensive safety check

When to switch to new version



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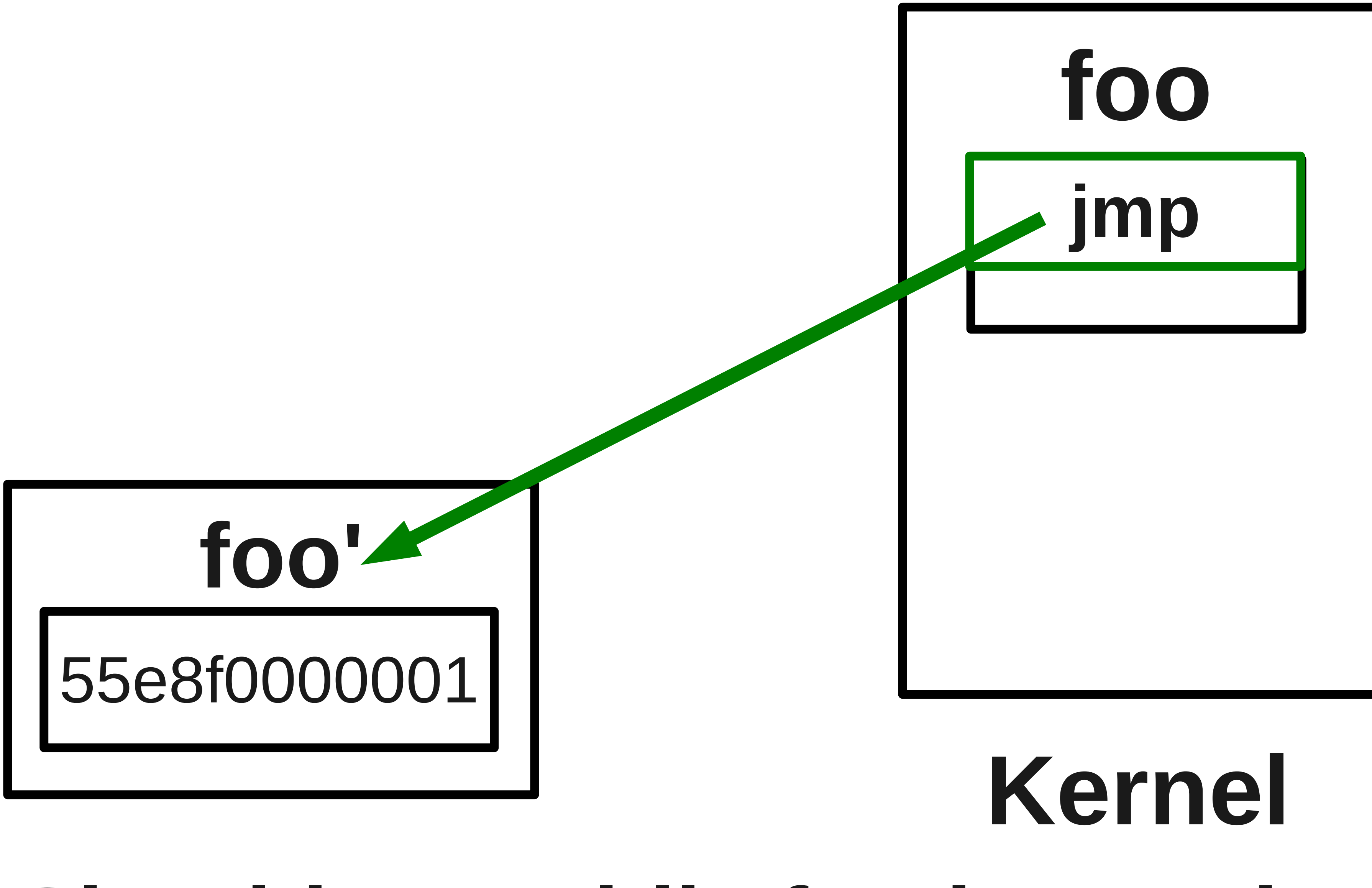

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- If necessary, abort (rare)
- Paused less than 0.7ms

Data structure changes

- Design so far only changes code—not data

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- Sometimes need to walk existing data structures, updating them:
  - Add a field to a struct
  - Change how a data structure is initialized

Ksplice support for data structure changes

- Simply modify the patch or add code to the patch
- Can use macros to run code when the update is applied
  - ksplice_pre_apply(func)
  - ksplice_apply(func)

  (and others...)

CVE-2006-1056 patch

```
--- a/arch/i386/kernel/cpu/amd.c
+++ b/arch/i386/kernel/cpu/amd.c
@@ -207,6 +207,9 @@ static void __init
  init_amd(struct cpuinfo_x86 *c)
...
+ if (c->x86 >= 6)
+   set_bit(X86_FEATURE_FXSAVE_LEAK,
+           c->x86_capability);
...
```

(and other changes)

```
+#include "ksplice-patch.h"
+static void set_fxsave_leak_bit(int id)
+{
+  int i;
+  for (i = 0; i < NR_CPUS; i++) {
+    struct cpuinfo_x86 *c =
+          cpu_data + i;
+    if (c->x86 >= 6 && c->x86_vendor ==
+          X86_VENDOR_AMD)
+      set_bit(X86_FEATURE_FXSAVE_LEAK,
+                c->x86_capability);
+  }
+}
+ksplice_apply(set_fxsave_leak_bit);
```

Adding fields to structs

```
 struct foo {
   int a;
+  int b;
 };
struct foo x[3];
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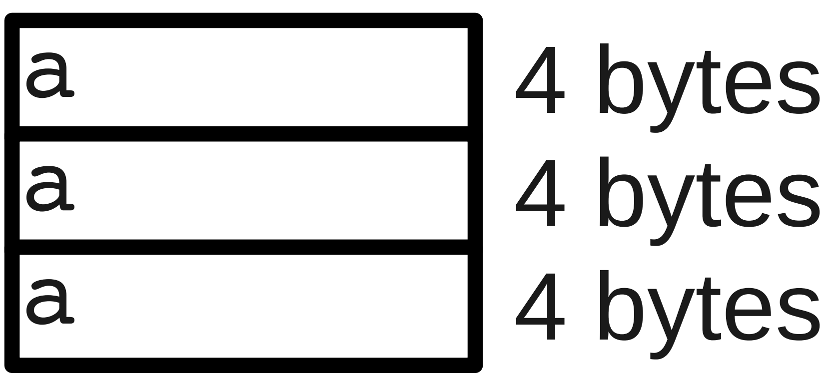

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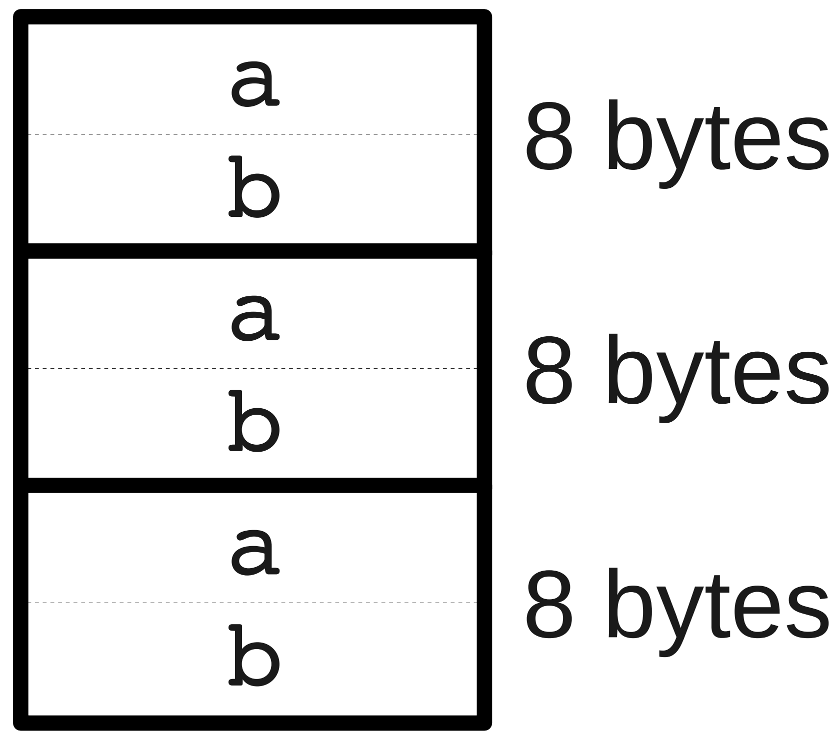

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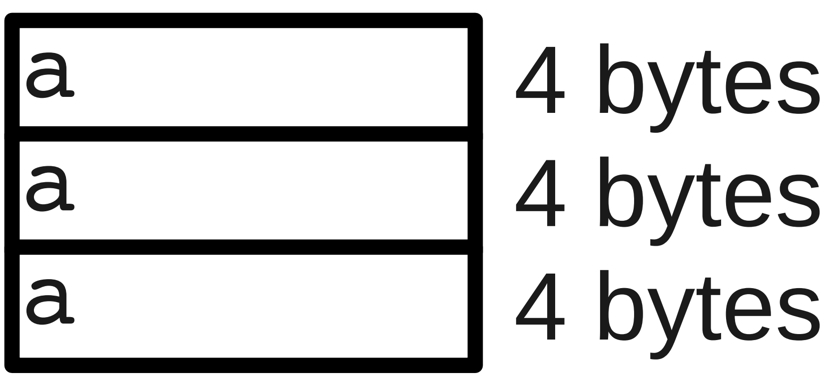

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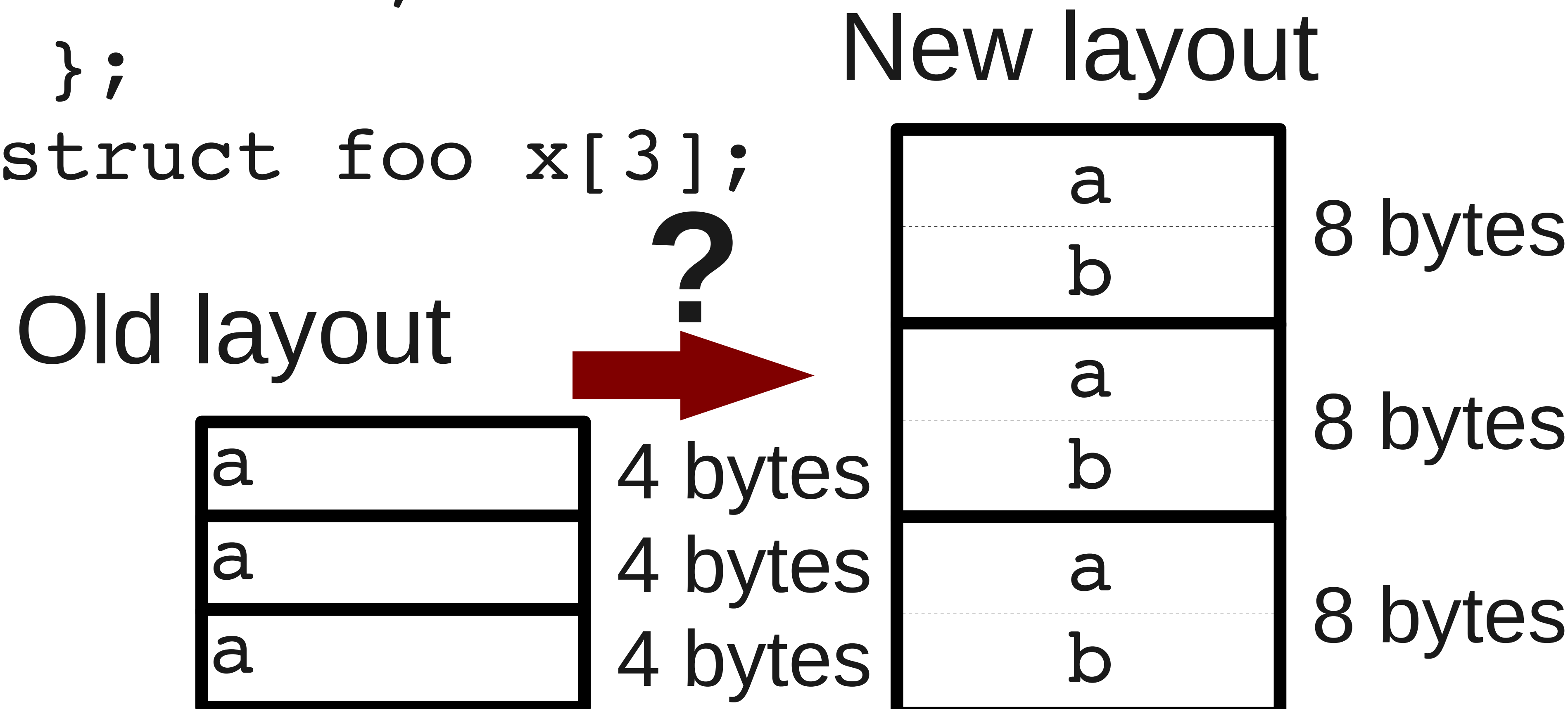

Shadow hashing

- “shadow” field(s) off to side

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- Lookup shadows by hashing the address of the structure instance (O(1) time)

  Old instance of struct foo at address 0xbeef

  b_hashtable{0xbeef}

Hypothesis

- Most Linux security patches can be hot-applied without writing much new code

- Interested in:
  - How many patches can be applied without any new code?
  - How much new code is needed to apply the other patches?

Methodology

- Matched all 'significant' CVEs against Linux patch commit logs

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- Generated a hot update for each CVE patch, confirming that:
  - Update applies cleanly
  - Still passes POSIX stress test
  - For available exploits: the exploit stops working

Summary of Results

- Hot-apply most security patches (88%) without any patch changes

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- Hot-apply 100% with modest programmer effort
(~17 lines of new code per patch)

CVEs that do not require any new code

2005-1263 2005-1264 2005-1589 2005-2456 2005-3276
2005-2500 2005-2492 2005-3179 2005-3180 2005-2709
2005-4639 2005-3784 2005-4605 2006-0095 2006-0457
2006-2071 2006-1524 2006-1056 2006-1863 2006-1864
2006-0039 2006-1857 2006-1858 2006-1343 2006-2935
2006-2451 2006-3626 2006-3745 2006-5751 2006-6304
2006-5753 2006-6106 2007-0958 2007-1217 2007-0005
2007-1000 2007-1730 2007-1734 2007-2480 2007-1353
2007-2875 2007-3105 2007-3851 2007-3848 2007-3740
2007-4571 2007-4308 2007-5904 2007-6206 2007-6417
2007-6063 2007-6434 2007-5966 2008-0001 2008-0007
2008-0009 2008-0600 2008-1367 2008-1675 2008-1375
2008-2148 2008-1669 2008-1294 2008-1673

CVEs needing new code

CVE #	Logical Lines
2008-0007	34
2007-4571	10
2007-3851	1
2006-5753	1
2006-2071	14
2006-1056	4
2005-3179	20
2005-2709	48

Debugging or Instrumenting

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- Advantages of Ksplice
  - Real C
  - Insert code almost anywhere
  - Discover any symbol value

Demos

- Protecting against x86 exploit
- Debugging on Android

Future plans

- Deliver existing technology

  Ksplice, Inc. starting to provide rebootless update service

- Continue advancing hot updates

  One goal: apply almost entire stable tree using Ksplice

Ksplice®

Acknowledgments

Frans Kaashoek
Tim Abbott
Anders Kaseorg
Waseem Daher
MIT SIPB

Massachusetts Institute of Technology

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