

Ksplice[®]

**Rebootless
kernel updates**

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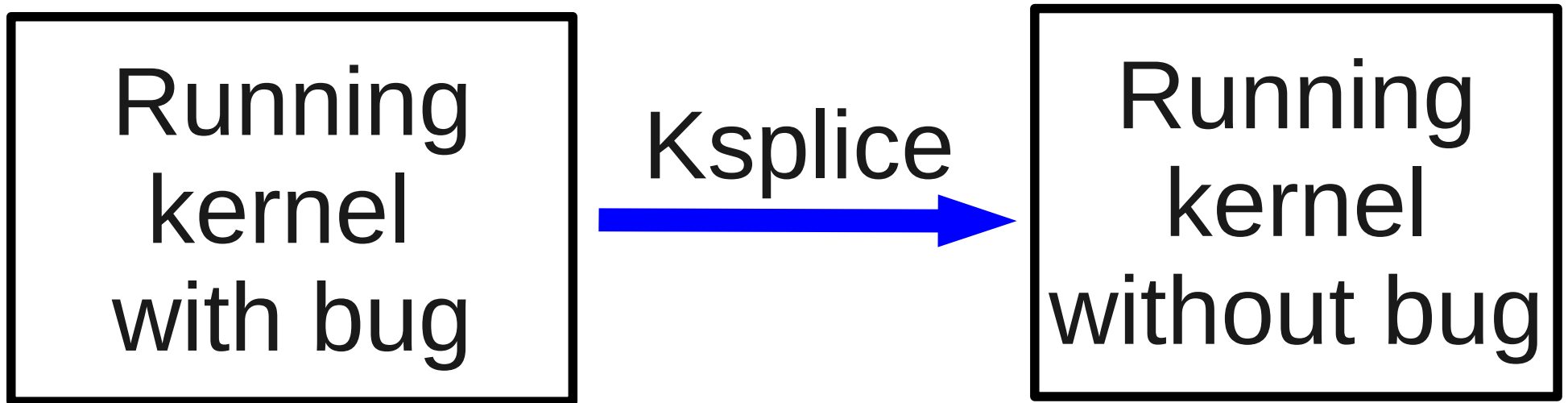
`http://www.ksplice.com`

What is Ksplice?

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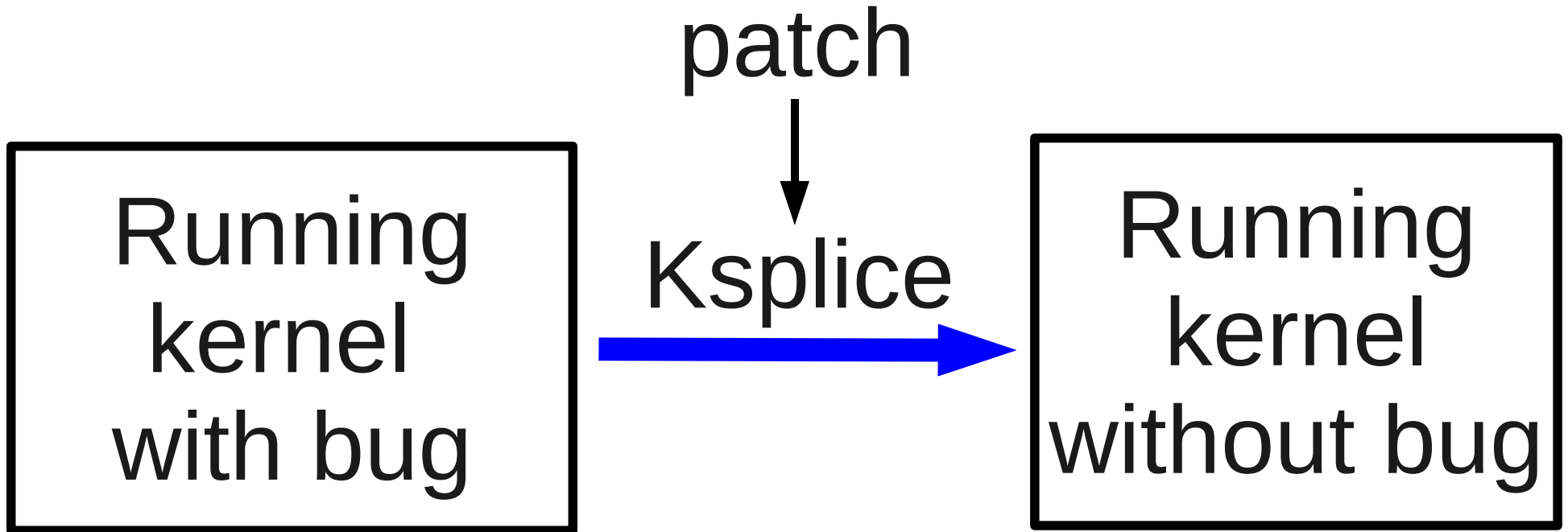
Running
kernel
with bug

What is Ksplice?



Update the kernel without disruption

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Update the kernel without disruption

Why should you care?

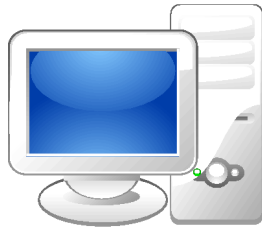
Why should you care?

- Eliminates the need to choose between security and convenience
 - Patch promptly
and
 - Avoid reboots

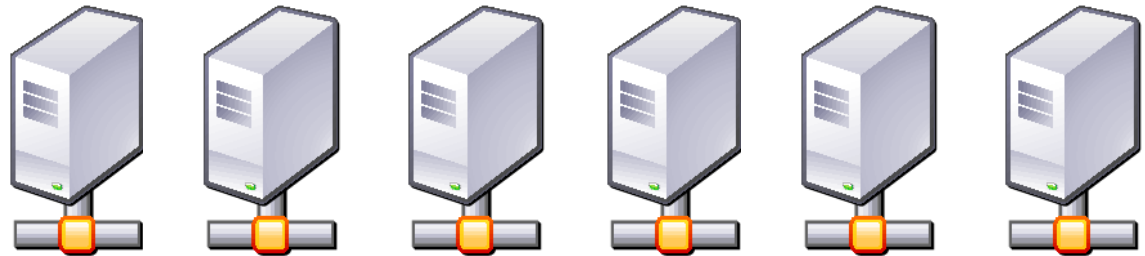
**Why is avoiding
reboots important?**

Why is avoiding reboots important?

- Downtime



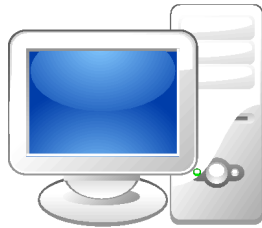
Few minutes



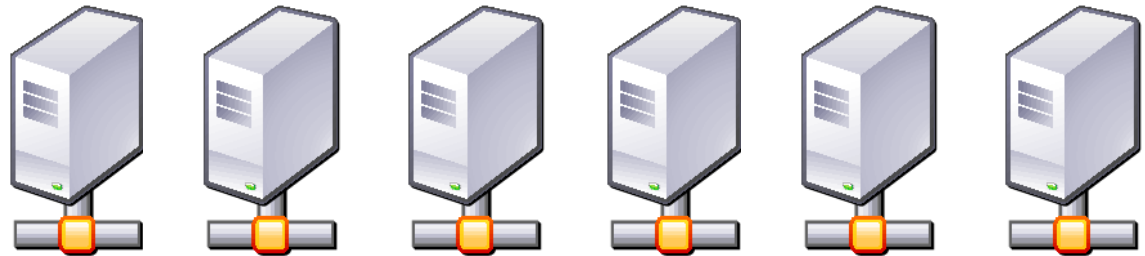
1-2 hour announced window
during off-peak hours

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Few minutes

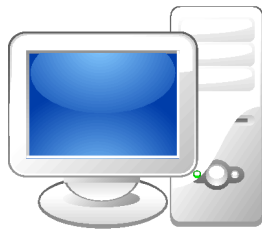


1-2 hour announced window
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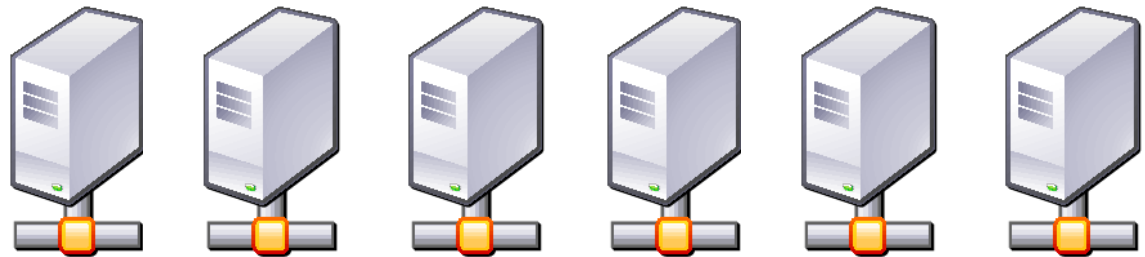
- Lose software state

Why is avoiding reboots important?

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Few minutes



1-2 hour announced window
during off-peak hours

- Lose software state
- Reboots commonly cause unexpected problems

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- > 90% of attacks exploit known vulnerabilities

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- Days or weeks: too long to wait

Features

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- Modules and assembly code
- Negligible performance impact

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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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user then becomes the superuser

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

```
Done!
```

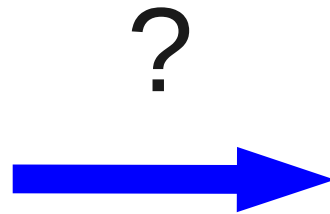
```
#
```

Demo: Protecting against an exploit

Demo: User experience

The Challenge

```
patch:  
- if(aa) {bb}  
+ if(cc) {dd}
```



```
457f46  
4c0102  
000100  
000002  
00e300
```

Kernel

The rest of this talk

- How Ksplice works
- Evaluation: 2005-2008 security vulnerabilities
- Using Ksplice for debugging
- Future plans

Design Outline

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- Generate a “replacement function” for every to-be-replaced function
- Start redirecting execution to the replacement functions

pre-post differencing

pre source

 post source

pre-post differencing

pre source

↓ gcc

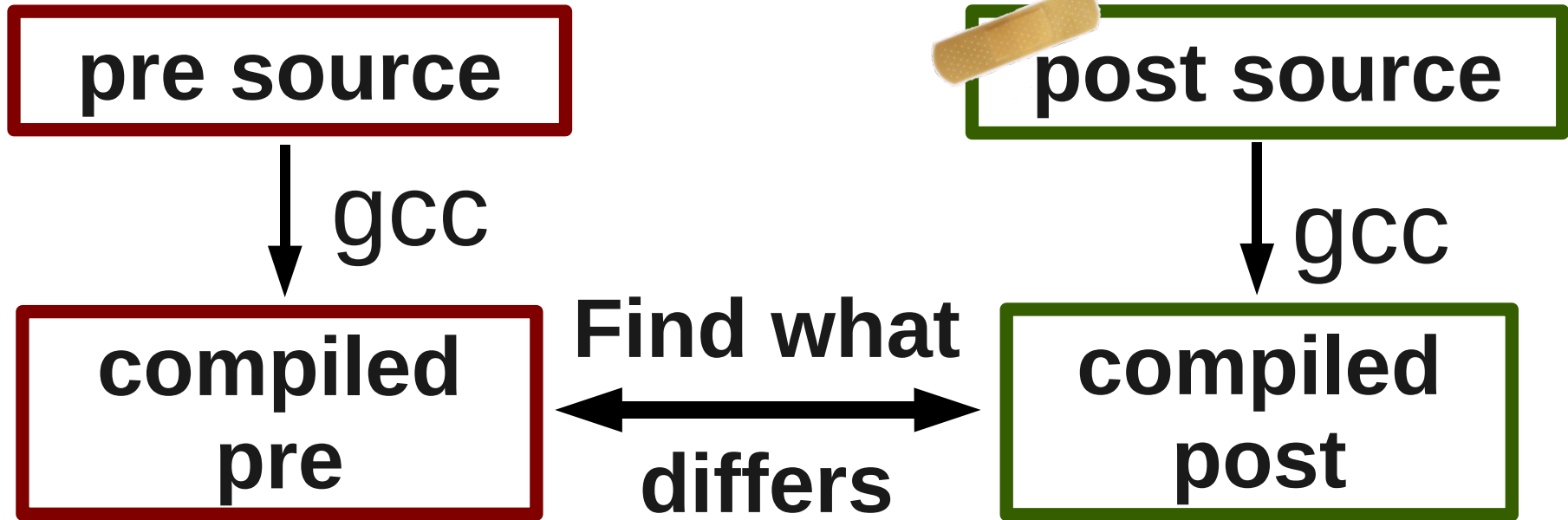
compiled
pre

 post source

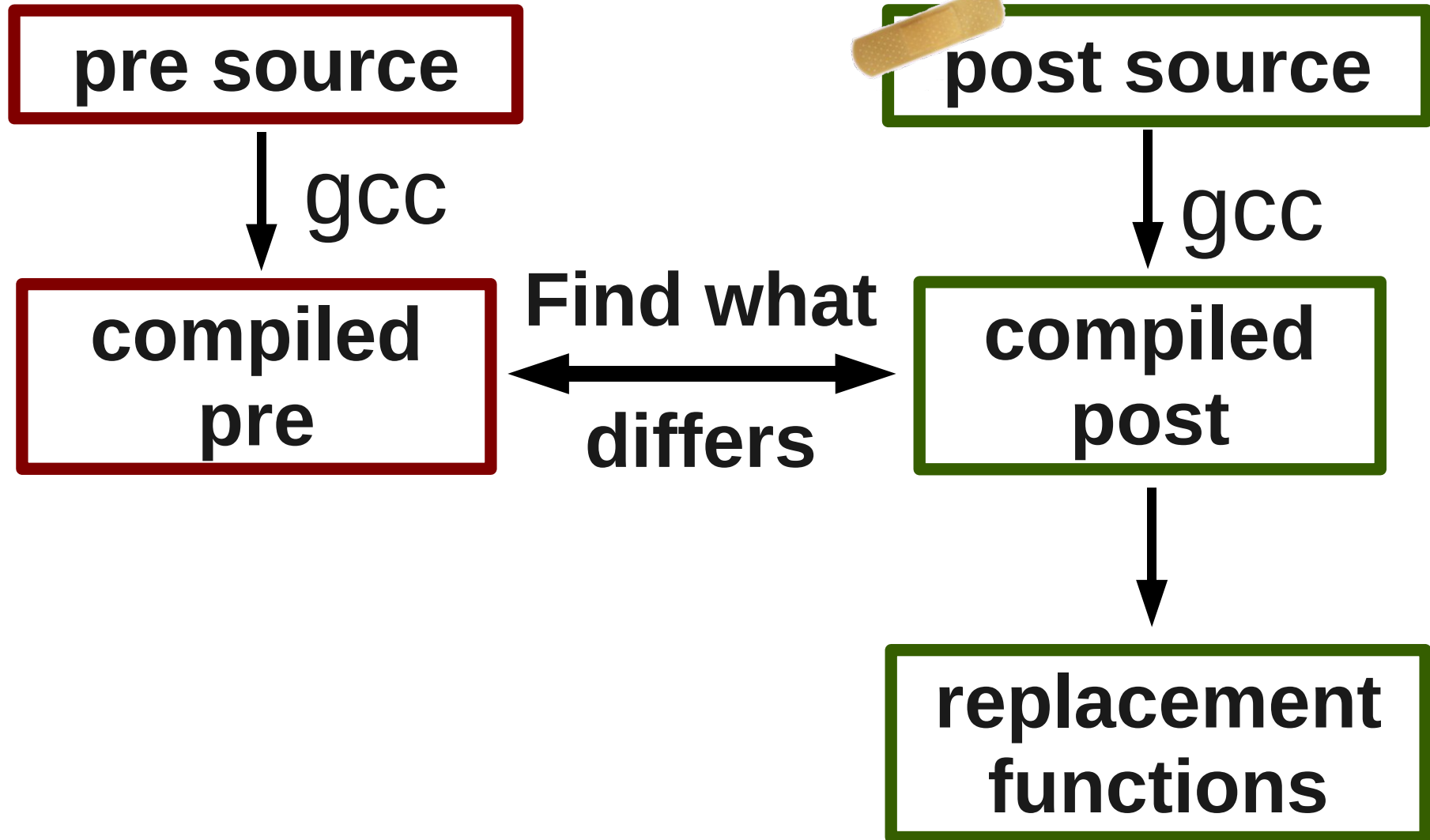
↓ gcc

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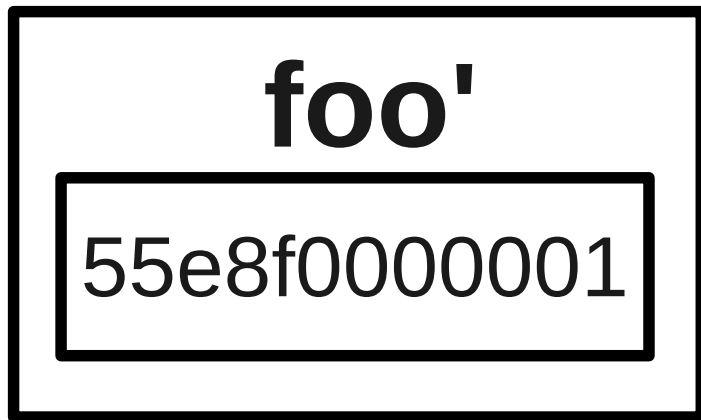
pre-post differencing



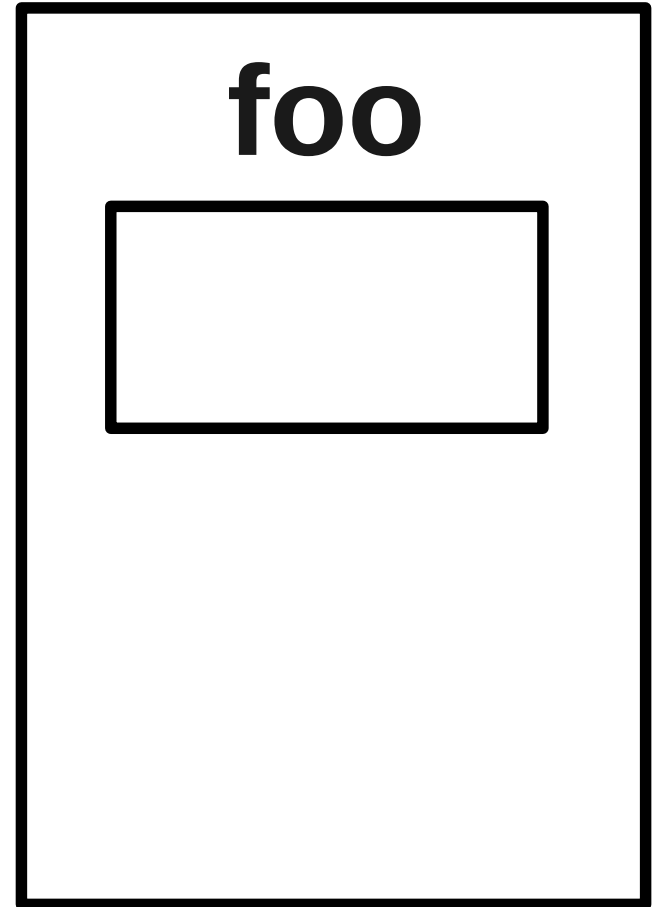
pre-post differencing



Redirect execution

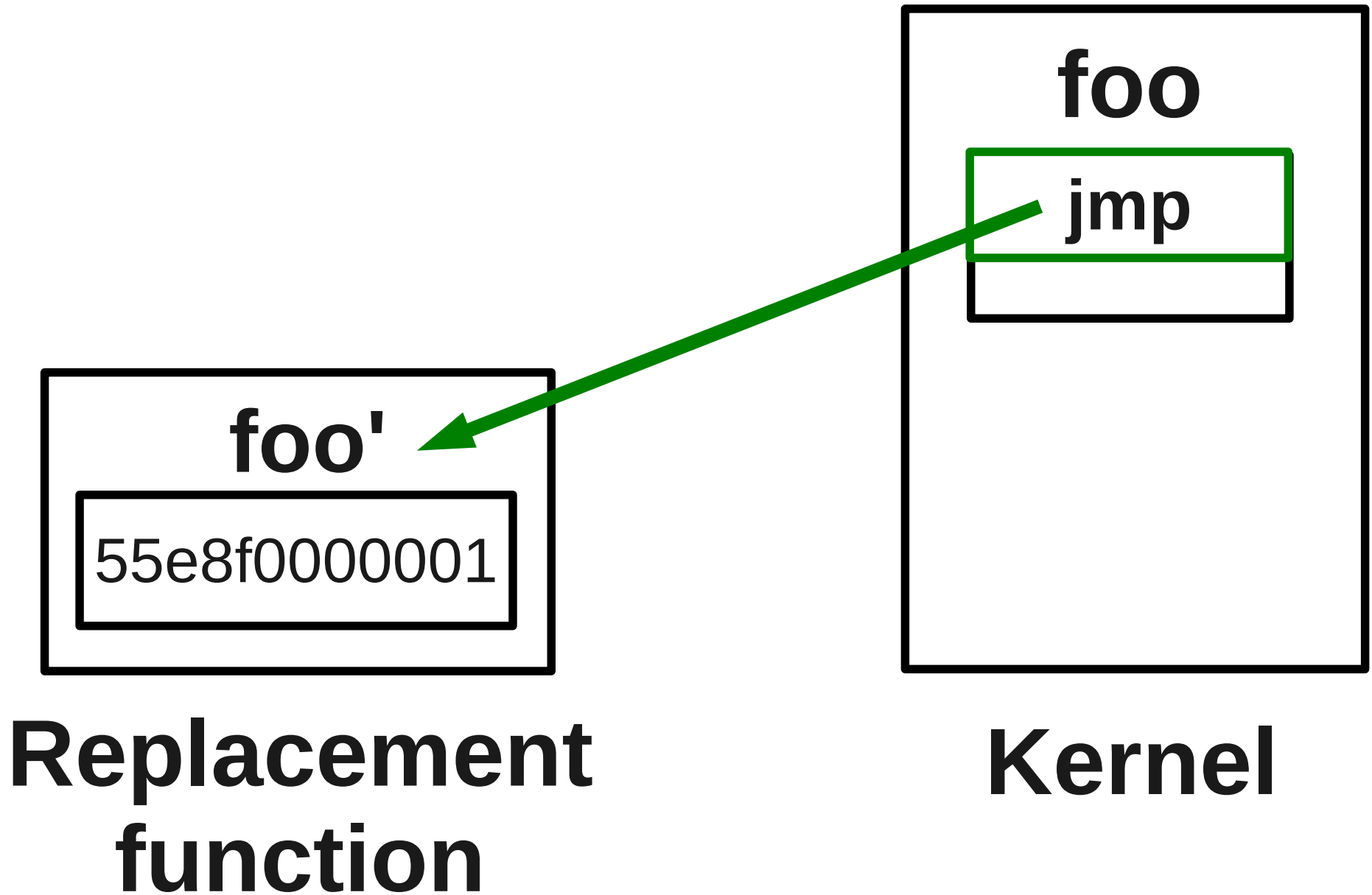


**Replacement
function**

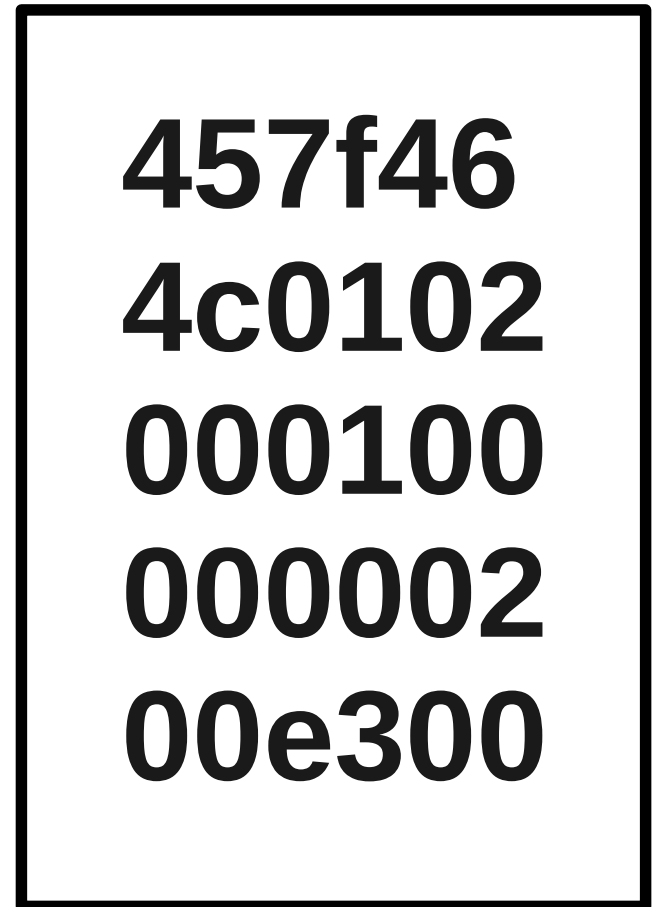


Kernel

Redirect execution



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]

...

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...

[bar]

...

**Any pre function X
from same scope:**

...

[bar]

...

replacement foo':

...

[bar]

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**Kernel's
running code:**

replacement foo':

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**Any pre function X
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**Kernel's
running code:**

[addr f0000000]

function X:

...

00 11 11 00

...

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...

bar = 00111100 + f0000002 - (-4)

replacement foo':

...

[bar]

...

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from same scope:**

...

[bar]

...

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running code:**

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$$\begin{aligned} \text{bar} &= 00111100 + \text{f0000002} - (-4) \\ &= \text{f0111106} \end{aligned}$$

**Kernel's
running code:**

[addr f0000000]
function X:

...

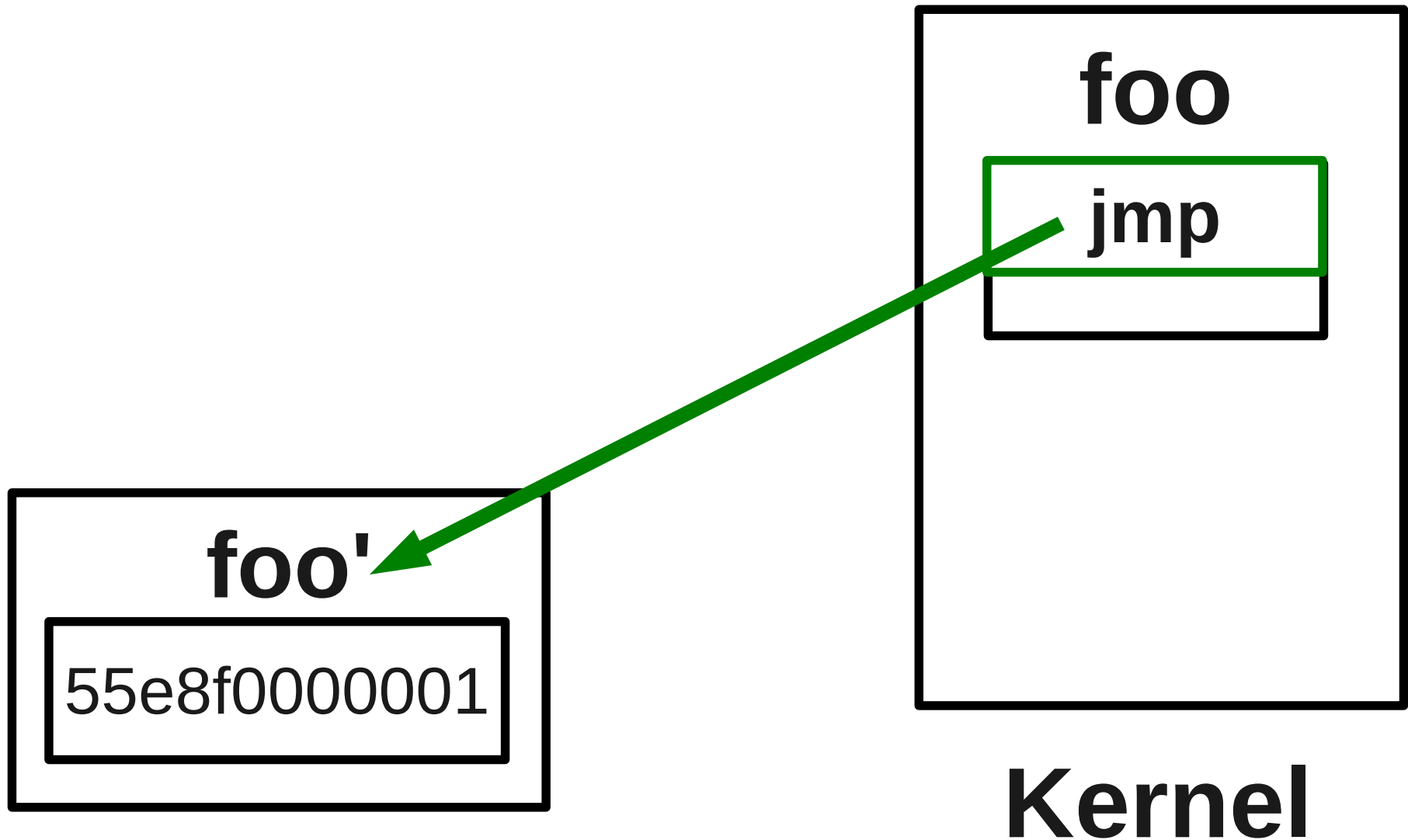
pre function X:

...



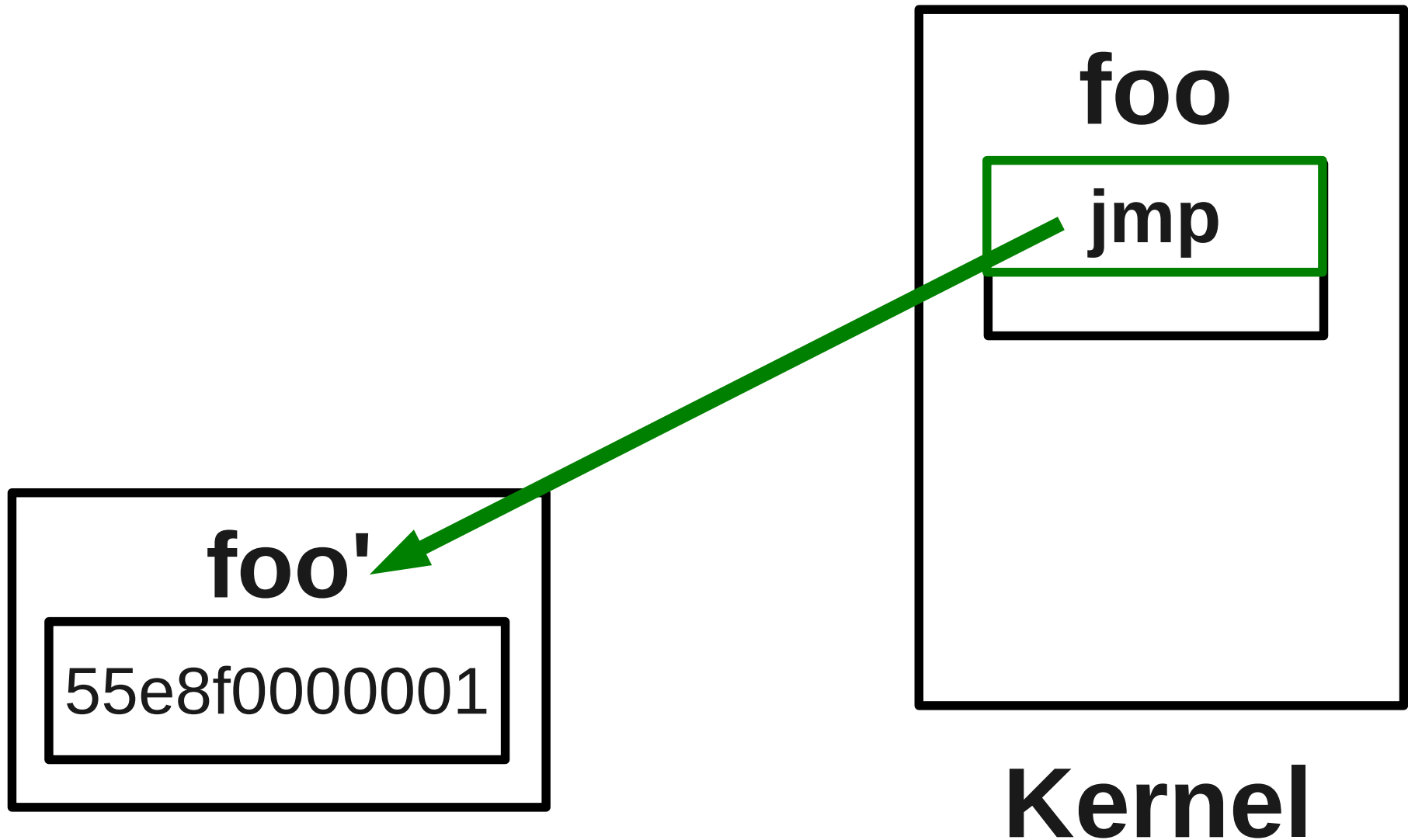
Also serves as extensive safety check

When to switch to new version



Should not while foo is running

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

Data structure changes

- Design described 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_FXS_SAVE_LEAK,
+                c->x86_capability);
+    }
+}
+ksplICE_apply(set_fxsave_leak_bit);
```

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

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 - Real C
 - Insert code almost anywhere
 - Discover any symbol value

Impact

- Not necessary to disrupt operations to stay secure
- Possible to keep systems fully patched using hot updates
- Technology also applies to user space applications

Future plans

- Deliver existing technology

Ksplice, Inc. starting to provide
rebootless update service

- Continue advancing hot updates

Important to be able to ensure
patch safety



Acknowledgments

Frans Kaashoek

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Waseem Daher

MIT SIPB



**Massachusetts
Institute of
Technology**

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