Hardening pkgsrc

Securing packages, 17.000 at a time

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About myself

- Pierre Pronchery, planet Earth
- DeforaOS Project since 2004
- IT-Security consultant since 2006
- NetBSD developer since May 2012
- Working on NetBSD with Git through the EdgeBSD community since August 2013
- Co-founder of Defora Networks since July 2016: https://www.defora.net/

Introduction

- pkgsrc is a multi-platform:
  - Software distribution
  - Build framework
  - Package manager
- Default source for packaged software on NetBSD, SmartOS, Minix...
- Supports many more!
  - Over 17.000 packages on 17+ platforms

Motivation

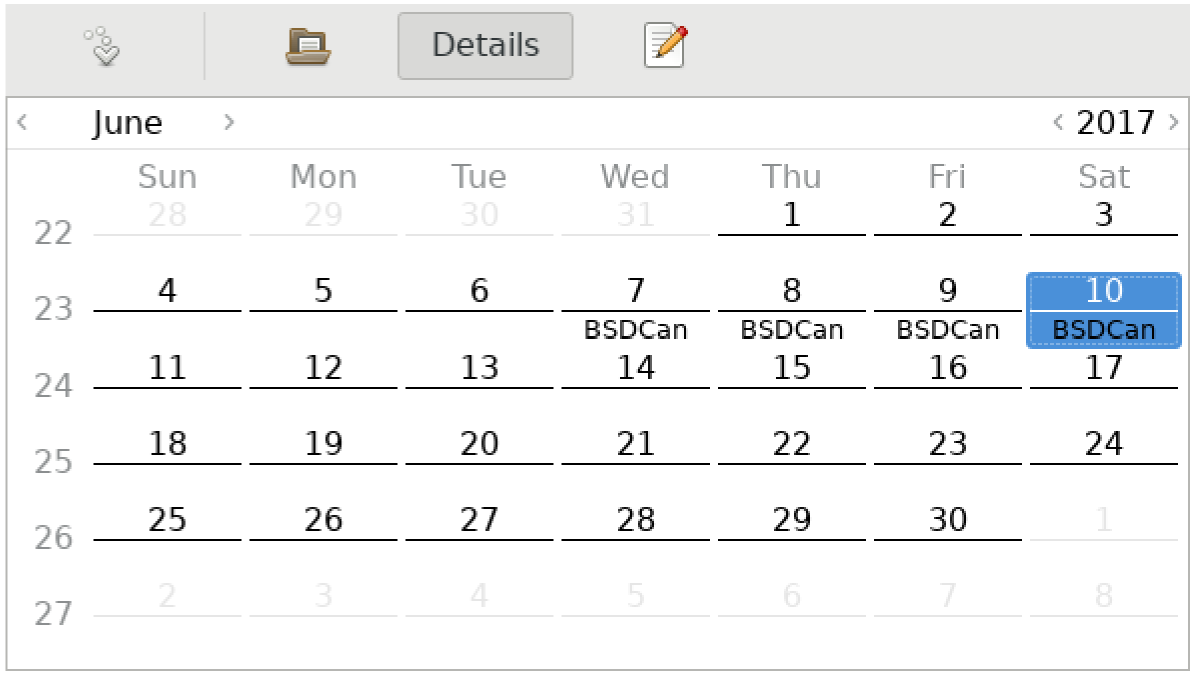
- As illustrated again in the news this week, a “**cyber-war**” is raging *right now*
- We have a responsibility towards our users
- pkgsrc offers a great opportunity for hardening a complete software setup

THE INDEPENDENT
'Prepare for all-out cyber war'
Government sites braced for attack by pro-WikiLeaks 'hacktivists'
The Economist
Cyberwar
The threat from the internet
TIME
HE'S GONE: Jerry Garcia Dead at 53
CYBER WAR
The U.S. rushes to turn computers into tomorrow's weapons of destruction. But how vulnerable is the home front?
ALLVOICES
CYBER WAR
THE NEXT THREAT TO NATIONAL SECURITY AND WHAT TO DO ABOUT IT
RICHARD A. CLARKE
AND ROBERT K. KNAKE
Surviving CYBER WAR

Agenda

1. Security management
   Processes in place
2. Hardening features
   Technical measures
3. Future work
   Perspectives for improvement

Questions & Answers



June 2017

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
22	28	29	30	31	1	2	3
23	4	5	6	7 BSDCan	8 BSDCan	9 BSDCan	10 BSDCan
24	11	12	13	14	15	16	17
25	18	19	20	21	22	23	24
26	25	26	27	28	29	30	1
27	2	3	4	5	6	7	8

1. Security management

1. Teams in charge
   - Security Team
   - Release Engineering Group
2. Vulnerability assessment database
   - Usage from source
   - Auditing binary packages
3. Maintenance of the stable release
   - Security patches
   - Long-Term Support (LTS)

pkgsrc Security Team

- List of duties:
  - Handles security issues relevant to pkgsrc:
    pkgsrc-security@NetBSD.org
    http://pkgsrc.org/pkgsrc-security_pgp_key.asc
  - Maintains the vulnerability database:
    http://cdn.netbsd.org/pub/NetBSD/packages/vulns/pkg-vu
    lnerabilities.bz2

Vulnerability database

- Assembled from:
  - Release notes from upstream packages
  - Security Advisories from vendors (Secunia...)
  - Announcements on public mailing-lists (OSS-Security...)
  - Erratas or advisories from other distributions, governmental or technical organisations (MITRE, CERT...)
- Cryptographically signed (PGP)

Vulnerability assessment

- Configure updates in `/etc/daily.conf`:

```
fetch_pkg_vulnerabilities=YES
```

- To fetch manually:

```
# pkg_admin fetch-pkg-vulnerabilities
-s
```

- To audit the packages installed:

```
# pkg_admin audit
```

Vulnerability assessment (from sources)

```
sysutils/xenkernel45$ make install
=> Bootstrap dependency digest>=20010302:
found digest-20160304
===> Checking for vulnerabilities in
xenkernel45-4.5.5nb1
Package xenkernel45-4.5.5nb1 has a information-leak
vulnerability, see
http://xenbits.xen.org/xsa/advisory-200.html
[…]
ERROR: Define ALLOW_VULNERABLE_PACKAGES in
/etc/mk.conf or IGNORE_URL in pkg_install.conf(5) if
this package is absolutely essential.
*** Error code 1
```

Vulnerability assessment (binary packages)

```
# pkg_add wireshark-2.2.1.tgz
Package wireshark-2.2.1 has a denial-
of-service vulnerability, see
https://www.wireshark.org/security/wn
pa-sec-2016-58.html
[…]
pkg_add: 1 package addition failed
```

Vulnerability assessment (binary packages)

- In `/etc/pkg_install.conf`:

```
CHECK_VULNERABILITIES=always
```

- Alternatively, set to `interactive` to be prompted:

```
[...]
Do you want to proceed with the
installation of wireshark-2.2.1 [y/n]?
n
Cancelling installation
pkg_add: 1 package addition failed
```

Security Team members

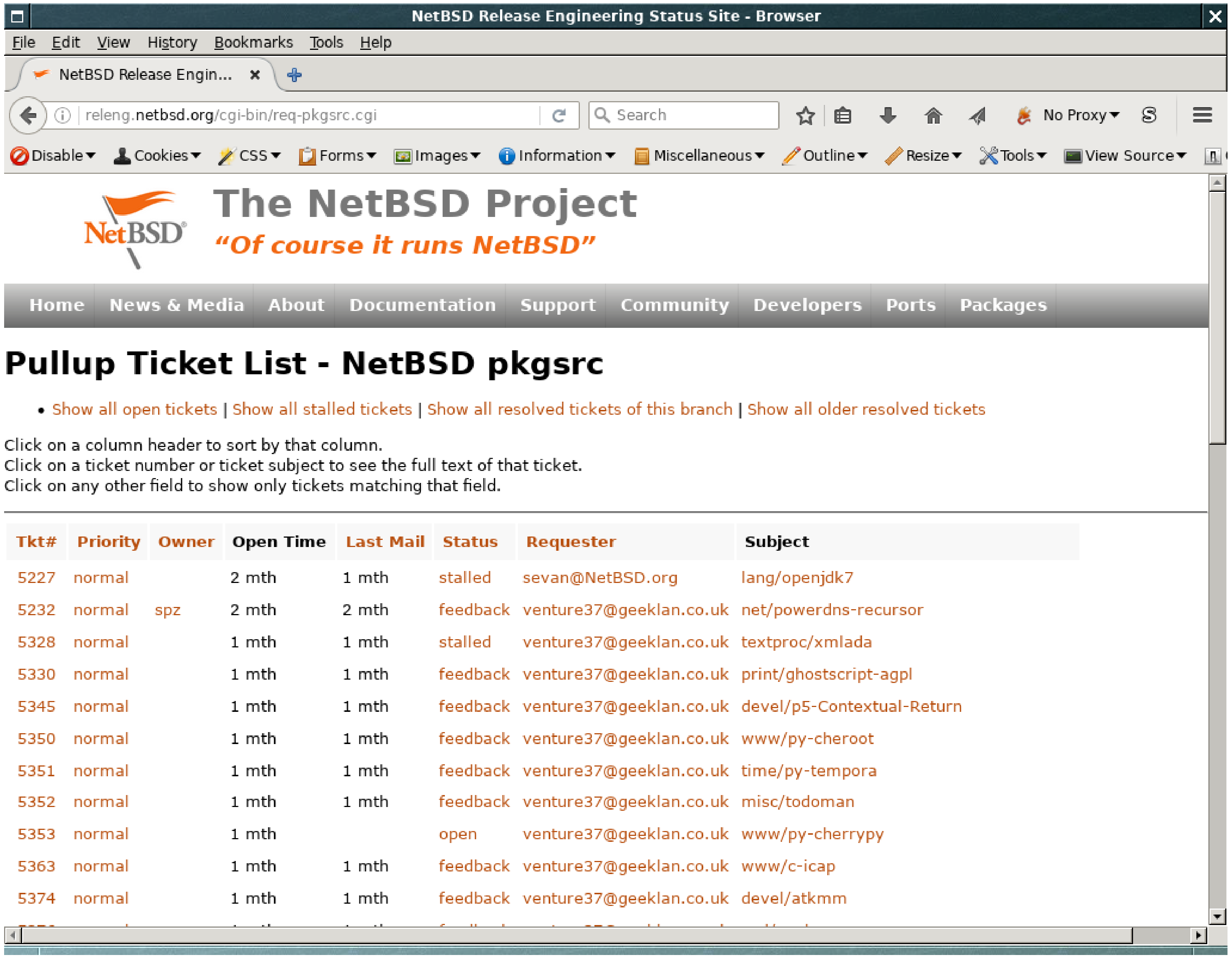
- Alistair G. Crooks <agc@>
- Daniel Horecki <morr@>
- Sevan Janiyan <sevan@>
- Thomas Klausner <wiz@>
- Tobias Nygren <tnn@>
- Ryo Onodera <ryoon@>
- Fredrik Pettai <pettai@>
- Jörg Sonnenberger <joerg@>
- Tim Zingelman <tez@>

NetBSD®

Release Engineering Group

- List of duties:
  - Manage stable branches
    https://releng.netbsd.org/cgi-bin/req-pkgsrc.cgi
  - Process pullup requests
    Including security issues
    https://www.netbsd.org/developers/releng/pullups.html#pkgsrc-releng
  - Schedule freeze periods
    https://www.pkgsrc.org/is-a-freeze-on/

Release Engineering Group


NetBSD Release Engineering Status Site - Browser
File Edit View History Bookmarks Tools Help
NetBSD Release Engin...
releng.netbsd.org/cgi-bin/req-pkgsrc.cgi
Search
No Proxy
Disable Cookies CSS Forms Images Information Miscellaneous Outline Resize Tools View Source
The NetBSD Project
"Of course it runs NetBSD"
Home News & Media About Documentation Support Community Developers Ports Packages

Pullup Ticket List - NetBSD pkgsrc

- Show all open tickets | Show all stalled tickets | Show all resolved tickets of this branch | Show all older resolved tickets

Click on a column header to sort by that column.
Click on a ticket number or ticket subject to see the full text of that ticket.
Click on any other field to show only tickets matching that field.

Tkt#	Priority	Owner	Open Time	Last Mail	Status	Requester	Subject
5227	normal		2 mth	1 mth	stalled	sevan@NetBSD.org	lang/openjdk7
5232	normal	spz	2 mth	2 mth	feedback	venture37@geeklan.co.uk	net/powerdns-recursor
5328	normal		1 mth	1 mth	stalled	venture37@geeklan.co.uk	textproc/xmlada
5330	normal		1 mth	1 mth	feedback	venture37@geeklan.co.uk	print/ghostscript-agpl
5345	normal		1 mth	1 mth	feedback	venture37@geeklan.co.uk	devel/p5-Contextual-Return
5350	normal		1 mth	1 mth	feedback	venture37@geeklan.co.uk	www/py-cheroot
5351	normal		1 mth	1 mth	feedback	venture37@geeklan.co.uk	time/py-tempora
5352	normal		1 mth	1 mth	feedback	venture37@geeklan.co.uk	misc/todoman
5353	normal		1 mth		open	venture37@geeklan.co.uk	www/py-cherrypy
5363	normal		1 mth	1 mth	feedback	venture37@geeklan.co.uk	www/c-icap
5374	normal		1 mth	1 mth	feedback	venture37@geeklan.co.uk	devel/atkmm

Stable releases

- Stable releases happening every quarter:
  - 2016Q4 no longer maintained
  - 2017Q1 latest stable
  - 2017Q2 in progress (HEAD)
- Joyent provides Long-Term Support (LTS)
  - joyent/feature/backports/20XXQ4
    https://github.com/joyent/pkgsrc
  - Focus on SmartOS

Release Engineering Group members

- Ryo Onodera <ryoon@>
- Fredrik Pettai <pettai@>
- Eric Schnoebelen <schnoebe@>
- Benny Siegert <bsiegert@>
- S.P. Zeidler <spz@>

2. Hardening features

1. Package signatures
2. Stack Smashing Protection (SSP)
3. Fortify
4. PIE (for ASLR)
5. RELRO and BIND_NOW

Package signatures

- Support introduced initially in 2001:
  - Based on X.509 certificates or GnuPG
- Ensures authenticity and integrity:
  - Critical when installing binaries over HTTP or FTP
- Used by Joyent on SmartOS since 2014Q4:
  - Patch to use libnetpgpverify instead of GnuPG
- Still using GnuPG to generate packages

Package signatures

- Chicken and egg problem with GnuPG:
  - Not available in base
  - Needs to be installed as a package to verify itself
- Adding support for netpgp instead:
  - Available in NetBSD’s base system
  - Command line wrapper available (`gpg2netpgp`)
  - Still requires some patches (work in progress)
  - Security issue remaining with detached signatures

Package signatures (creation)

- Generate a key for the user building packages:
  ```
  $ gpg --gen-key
  ```
- In `/etc/mk.conf`:
  ```
  SIGN_PACKAGES=gpg
  ```
- Optionally, in `/etc/pkg_install.conf`:
  ```
  GPG=/usr/pkg/bin/gpg
  #GPG=/usr/local/bin/gpg2netpgp
  GPG_SIGN_AS=DEADBEEF
  ```
- Then use pkgsrc from source normally

Package signatures (installation)

- Import the key for the user installing packages:
```
# gpg --import
```
- In `/etc/pkg_install.conf`:
```
VERIFIED_INSTALLATION=always
```
- Then use pkgsrc normally:
```
# pkg_add socat
gpg: Signature made Thu Nov  3 14:44:06 2016 CET
using RSA key ID CC245448
gpg: Good signature from "EdgeBSD test packages
(khorben) <root@edgebsd.org>"
Primary key fingerprint: 968C 30DE B3C9 C147 203A
2E6E 5FFC 2014 CC24 5448
```

Stack Smashing Protection (SSP)

- Mitigation: reduce the impact and exploitation of Buffer Overflow vulnerabilities
- Different memory layout (stack variables)
- Addition of a « canary » value
  - Marker to detect memory corruption
  - Slight performance penalty
  - Controlled crashes instead of Code Execution

Stack Smashing Protection (SSP)

- Supported in pkgsrc for Linux (x86), FreeBSD (x86), and NetBSD
- Enabled in `/etc/mk.conf`:
  `PKGSRC_USE_SSP=yes`
- Sets a compilation flag, in the case of GCC and clang:
  `-fstack-protector`
  (protects only some functions)
- **Requires the package to support `CFLAGS`**
  Some packages still do not ☹

Stack Smashing Protection (challenges)

- Only protects C/C++ programs and interpreters
  - JIT compilation is not protected
- Supporting more flags:
  `-fstack-protector-all`
  (protects every function, now supported)
  `-fstack-protector-strong`
  (balanced, requires patch from Google)
- Add support for more compilers and platforms

Stack Smashing Protection (validation)

- To confirm a binary was successfully compiled with SSP:

```
$ nm hello
[…]
         U __stack_chk_fail
00600f00 B __stack_chk_guard
```

This is specific to GCC on NetBSD

- Enabled by default in OpenBSD (2003), Fedora and Ubuntu Linux (2006), DragonFlyBSD (2013)

Fortify

- Automatically adds boundary checks: `sprintf()`, `strncat()`, `memmove()`...
- Completely mitigates some Buffer Overflows
- Involves support from the libc (system headers)
  - Negligible performance impact
  - Controlled crashes instead of memory corruption

Fortify

- Supported in pkgsrc for Linux and NetBSD (GCC)
- Enabled in `/etc/mk.conf`:
  `PKGSRC_USE_FORTIFY=yes`
- Sets a pre-processing flag, in the case of GCC:
  `-D_FORTIFY_SOURCE=2`
- **Requires the package to support `CFLAGS`**
  Just like SSP ☹

Fortify (challenges)

- Only protects C/C++ programs and interpreters
  - Again JIT compilation is not protected
  - Requires an optimization level of 1 or more (e.g. `-O2`)
- Supporting more levels now possible in pkgsrc:
  `-D_FORTIFY_SOURCE=1`
  (protects fewer cases)
  `-D_FORTIFY_SOURCE=2`
  (some conforming programs might fail)
- Add support for more compilers and platforms

Fortify (validation)

- To confirm a binary was successfully compiled with Fortify:

```
$ nm hello
[…]
             U __sprintf_chk
```

This is specific to GCC on NetBSD

- Enabled by default in Ubuntu Linux and Android

Position-Independent Executables (PIE)

- Necessary companion to PaX ASLR (Address Space Layout Randomization)
- PaX ASLR enabled by default in NetBSD 8 (incoming!)
- Allow compiled binaries to be re-positioned dynamically in memory
- Makes exploitation more difficult (requires a memory leak including pointer values)
- Involves compilation **and linking** phases

Position-Independent Executables

- Supported in pkgsrc for NetBSD and GCC
- Enabled in `/etc/mk.conf`:
  `PKGSRC_MKPIE=yes`
- Sets a compilation flag, in the case of GCC:
  `-fPIC`
- Requires the package to support both `CFLAGS` **and `LDFLAGS` as well (with a caveat)**
  Even stricter than SSP and Fortify ☹

Position-Independent Executables (challenges)

- The compilation flag should really be `-fPIE` for executables
- The linking phase must be completed with `-pie` but **only for executables** so **not directly through `LDFLAGS`**
- Currently implemented in the GCC wrapper
- **Not supported in cwrappers** yet (patch in review)

Position-Independent Executables (advantages)

- Packages linked but not compiled correctly will **fail to build**
- Great way to know which packages do not implement flags as they should
- Program crashes usually reveal silent bugs
- Can be combined with `paxctl` otherwise:
  `NOT_PAX_ASLR_SAFE`
  `NOT_PAX_MPROTECT_SAFE`
  (see `mk/pax.mk`)

Position-Independent Executables (validation)

- To confirm an executable binary is a PIE:

```
$ file hello-pie
ELF 64-bit LSB shared object, x86-64,
version 1 (SYSV), dynamically linked (uses
shared libs), for NetBSD 7.0, not stripped

$ file hello-nopie
ELF 64-bit LSB executable, x86-64, version
1 (SYSV), dynamically linked (uses shared
libs), for NetBSD 7.0, not stripped
```

RELRO and BIND_NOW

- RELRO protects ELF executable programs from tampering at run-time
- Makes exploitation harder by reducing the attack surface through relocations
- Benefits from immediate binding with BIND_NOW
- Performance penalty when starting big programs
- Involves the **linking** phase

RELRO and BIND_NOW

- Supported in pkgsrc for Linux and NetBSD (GCC)
- Enabled in `/etc/mk.conf`:
  `PKGSRC_USE_RELRO=yes`
- Sets two linking flags, in the case of GCC:
  `-Wl,-z,relro -Wl,-z,now`
- Requires the package to support `LDFLAGS`

RELRO and BIND_NOW (challenges)

- More granularity is now supported:
  - Full, or
  - Partial (without BIND_NOW)
- Some packages break at run-time with full RELRO (e.g. Xorg)
- Could be adapted to more platforms
- Same issue as before with support from packages ☹

RELRO and BIND_NOW (validation)

- To confirm a binary was built with RELRO and BIND_NOW:

```
$ objdump -x hello
[…]
Program Header: […]
   RELRO off    0x00000d68
         vaddr  0x00600d68
         paddr  0x00600d68 align 2**0
         filesz 0x00000298
         memsz  0x00000298 flags r--
[…]
Dynamic Section: […]
  BIND_NOW              0x00000000
```

edgebsd/hardening

- Package meant to test a local pkgsrc setup: https://git.edgebsd.org/gitweb/?p=edgebsd.git;a=tree;f=hardening

```
$ hardening
[!] Hi! I am a library.
[!] Let's see if I am strong enough...
[+] built with -fPIC
[!] Bye! I am not a library anymore.
[!] Hi! I am an executable.
[+] built with -fPIC, good enough for full ASLR
[+] built with _FORTIFY_SOURCE 2, all good
[+] mmap() failed W|X, good
[-] mmap() gave two identical addresses :(
```

Demo

- Let us pray the demo gods?
- This presentation is the demo
- Userland with every feature mentioned so far (except Modular Xorg with partial RELRO)
- All the way to LibreOffice 5.3.0.3

3. Future work

- Reproducible Builds
- Code Flow Integrity (CFI)
- SafeStack
- Address Sanitizer

Reproducible Builds

« Reproducible builds are a set of software development practices that create a verifiable path from human readable source code to the binary code used by computers. »

- More at https://reproducible-builds.org/

Reproducible Builds

1. Deterministic build system:
   - Always the same result from a given source (including the current date and time, ordering of output...)
2. Pre-defined (or recorded) build environment:
   - Specific file format for build definitions
3. Let users reproduce and verify the original build

Reproducible Builds

- Already implemented in FreeBSD’s ports:
  - Initial patch takes the timestamp from `distinfo`
  - Specific patches needed as well (Perl...)
- Can affect many aspects of the build process:
  - Build environment: setting `$SOURCE_DATE_EPOCH`
  - Some flags relevant for GCC:
    - `gcc -Wp,-iremap,…`
    - `gcc -fdebug-prefix-map=…`

Code Flow Integrity (CFI)

- Prevents exploits from redirecting the execution flow of programs
- Controlled crashes instead of undefined behaviour
- Again, pkgsrc should be a great test-bed for this feature

Code Flow Integrity (Clang)

- Implementation available in Clang:
  http://clang.llvm.org/docs/ControlFlowIntegrity.html
- Requires the following in `CFLAGS`:
  `-flto -fsanitize=cfi`
  (individual schemes can be selected)
  and possibly `-fvisibility=hidden`
- Additional debugging information can be obtained
- Suitable for release builds:
  - Negligible performance impact

SafeStack (Clang)

- « An instrumentation pass that protects programs against attacks based on stack buffer overflows, without introducing any measurable performance overhead. It works by separating the program stack into two distinct regions: the safe stack and the unsafe stack. The safe stack stores return addresses, register spills, and local variables that are always accessed in a safe way, while the unsafe stack stores everything else. This separation ensures that buffer overflows on the unsafe stack cannot be used to overwrite anything on the safe stack. »
  https://clang.llvm.org/docs/SafeStack.html
- Involves `CFLAGS`:
  `-fsanitize=safe-stack`

Address Sanitizer (GCC)

- A memory error detector from GCC: https://gcc.gnu.org/onlinedocs/gcc/Instrumentation-Options.html
- Instruments memory access instructions
- Detects out-of-bounds and use-after-free bugs
- Involves `CFLAGS`: `-fsanitize=address` (more schemes are supported)

Closing words

- pkgsrc is a great project for testing security features
- Some possibilities can already be enabled *could some of them be turned on by default?*
- A lot more can still be done!

Thank you!

- BSDCan 2017: http://www.bsdcan.org/2017/
- pkgsrc: https://pkgsrc.org/
  - The pkgsrc Security Team & the Release Engineering Group
- Joyent: https://pkgsrc.joyent.com/
  - Jonathan Perkin <jperkin@>
- Devio.us, EdgeBSD, HardenedBSD, OpenBSD...
- Contact me at khorben@NetBSD.org
- Time for questions?