Unix Tools for Probing Executable Files

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Abstract

Unix offers many tools for the exploration of executable files, some of which depend upon the application being compiled with debug information. A brief survey follows. The `man`ual pages are included, making this document useful in siloed computing networks.

Contents

1 Overview

Unix provides powerful tools for probing executable files. The following section shows sample usage for each command and the final section contains the information from the manual page. The final element is the GNU debugger and not a formal element of Unix.

1. `env`
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3. `lddconfig`
4. `locate`
5. `objdump`
6. `lsof`
7. `readelf`
8. `nm`
9. `strace`
10. `strings`
11. `gdb`

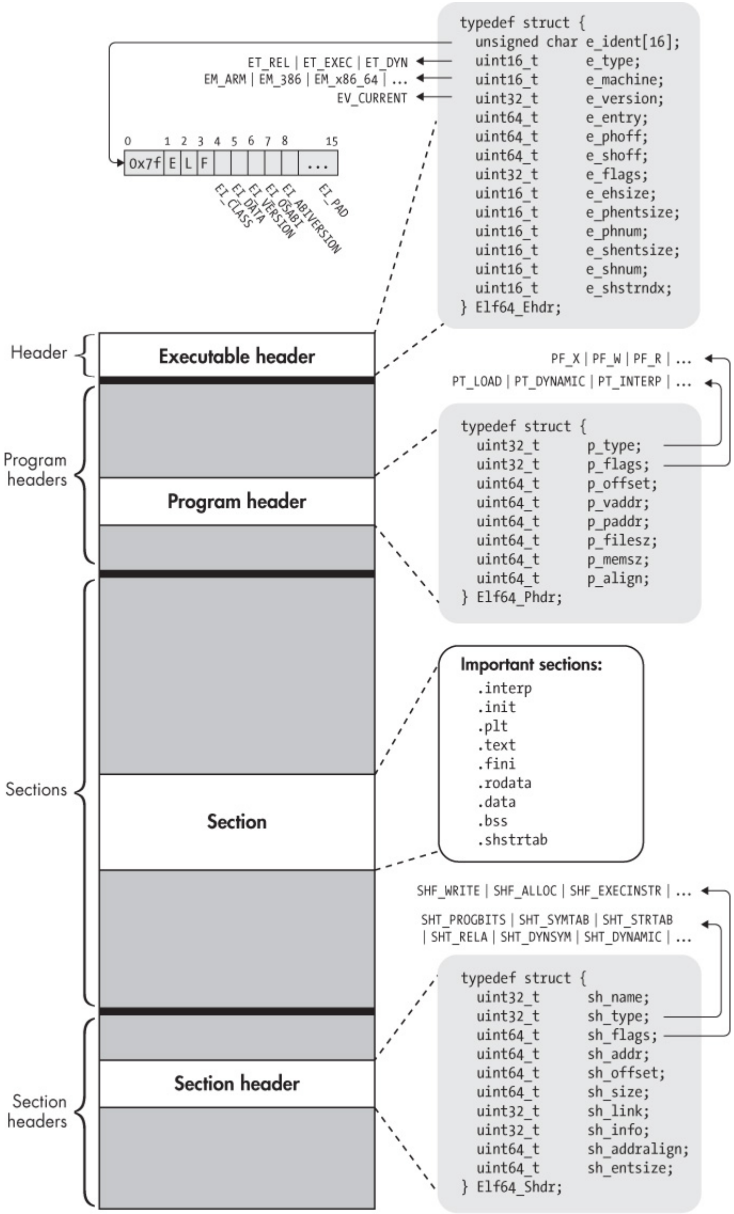
The goal is to be able to resolve the workings of an executable file exploiting the ELF structure show in figures 1. The next figure, 2, shows the relationship between source files, header files, shared objects, and the executable program.

2 Command Examples

2.1 env

A good starting point in debugging is to list environment variables with the command `env` to show where your application is looking for files and libraries. Most prominent are `RPATH` and `LD_LIBRARY_PATH`. These variables can be manipulated using `chrpath` or `patchelf`.

```
dantopa@Quaxolotl.local:~ $ env
build=23A344
bold=
d_python=/Volumes/T7-Touch/repos/github/python
MAC=ac:de:48:00:11:22
dirLsIo=/Users/dantopa/Mathematica_files/io/projects/least squares
gf=/Volumes/T7-Touch/repos/github/f
dbase=dantopa/base-centos:8.5
TERM_PROGRAM=Apple_Terminal
gflags=-g -ffpe-trap=denormal,invalid,zero -fbacktrace -Wall -Wextra -Waliasing -Wsurprising -Wimplicit-procedure -Wi
```


Header
Executable header
Program headers
Program header
Sections
Section
Section headers
Section header
ET_REL | ET_EXEC | ET_DYN
EM_ARM | EM_386 | EM_x86_64 | ...
EV_CURRENT
0 1 2 3 4 5 6 7 8 15
0x7f E L F ...
EI_CLASS
EI_DATA
EI_VERSION
EI_OSABI
EI_ABIVERSION
EI_PAD
PF_X | PF_W | PF_R | ...
PT_LOAD | PT_DYNAMIC | PT_INTERP | ...
SHF_WRITE | SHF_ALLOC | SHF_EXECINSTR | ...
SHT_PROGBITS | SHT_SYMTAB | SHT_STRTAB
| SHT_RELA | SHT_DYNSYM | SHT_DYNAMIC | ...

```
typedef struct {
  unsigned char e_ident[16];
  uint16_t      e_type;
  uint16_t      e_machine;
  uint32_t      e_version;
  uint64_t      e_entry;
  uint64_t      e_phoff;
  uint64_t      e_shoff;
  uint32_t      e_flags;
  uint16_t      e_ehsize;
  uint16_t      e_phentsize;
  uint16_t      e_phnum;
  uint16_t      e_shentsize;
  uint16_t      e_shnum;
  uint16_t      e_shstrndx;
} Elf64_Ehdr;
```

```
typedef struct {
  uint32_t      p_type;
  uint32_t      p_flags;
  uint64_t      p_offset;
  uint64_t      p_vaddr;
  uint64_t      p_paddr;
  uint64_t      p_filesz;
  uint64_t      p_memsz;
  uint64_t      p_align;
} Elf64_Phdr;
```

Important sections:

```
.interp
.init
.plt
.text
.fini
.rodata
.data
.bss
.shstrtab
```

```
typedef struct {
  uint32_t      sh_name;
  uint32_t      sh_type;
  uint64_t      sh_flags;
  uint64_t      sh_addr;
  uint64_t      sh_offset;
  uint64_t      sh_size;
  uint32_t      sh_link;
  uint32_t      sh_info;
  uint64_t      sh_addralign;
  uint64_t      sh_entsize;
} Elf64_Shdr;
```

Figure 1: The structure of a Unix ELF file.

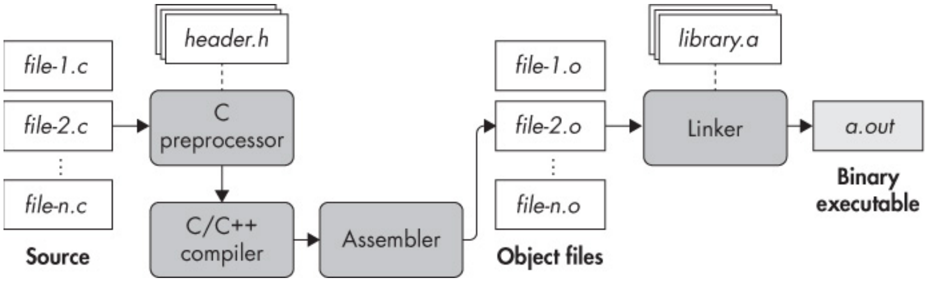


Figure 2: Connecting source files, object files, libraries, and bindary executables.

```
dirDockerLocker=
centos_version=8.5
my_log=/Users/dantopa/.info/modules-list.txt
SHELL=/bin/bash
TERM=xterm-256color
machine=MacBookPro16,1
cppflags=-g -Wall -Wextra -Og -pedantic -fmax-errors=5# -fdiagnostics-color=auto
local_spack=/Volumes/T7-Touch/spacktivity/spack-quaxolotl-darwin
TMPDIR=/var/folders/ld/z0sr6fhn0rz4tndl4nfm941m0000gn/T/
reconstructor=/Volumes/T7-Touch/repos/github/reconstructor
repo_results_docker=/Volumes/T7-Touch/repos/github/builds/results-docker
drive_int=Macintosh HD
TERM_PROGRAM_VERSION=453
astra=/Volumes/T7-Touch/repos/github/astra-spack-mirror
gitlab=/Volumes/T7-Touch/repos/gitlab
TERM_SESSION_ID=178C575A-C566-4D30-90CD-2FEB7C9D4E30
os=darwin
gflags48=-g -ffpe-trap=denormal,invalid,zero -fbacktrace -Wall -Wextra -Waliasing -Wsurprising -Wimplicit-procedure -
normal=
USER=dantopa
debian_version=11.3
dir_config=MacBookPro16,1-(quaxolotl)/darwin-23.0.0/Sonoma-14.0.0
jop=/Volumes/T7-Touch/repos/github/jop
lrepos=/Users/dantopa/repos
moniker=quaxolotl
SSH_AUTH_SOCK=/private/tmp/com.apple.launchd.XDYmj6zGeg/Listeners
dcker=/Volumes/T7-Touch/repos/github/docker/unified
repos_bitbucket= icons placemat
bitbucket=/Volumes/T7-Touch/repos/bitbucket
repo_scripts_spack=/Volumes/T7-Touch/repos/github/builds/scripts-spack
drive_ext=T7-Touch
gflags45=-g -ffpe-trap=denormal,invalid,zero -fbacktrace -Wall -Wextra -Waliasing -Wsurprising -Wimplicit-procedure -
repo_build=/Volumes/T7-Touch/repos/github/builds
PATH=/opt/local/bin:/opt/local/sbin:/opt/local/bin:/opt/local/sbin:/usr/local/bin:/System/Cryptexes/App/usr/bin:/usr/
scratch=/Users/dantopa/scratch
volume_ext=/Volumes/T7-Touch
PWD=/Users/dantopa
repo_results_spack=/Volumes/T7-Touch/repos/github/builds/results-spack
mySpack=/Volumes/T7-Touch/spacktivity
capulin_gitlab=dantopa@wtrw:cp-fe:/users/dantopa/repos/gitlab
LANG=en_US.UTF-8
github=/Volumes/T7-Touch/repos/github
serial_num=C02CR18HMD6
```

```
capulin=dantopa@wtrw:cp-fe:
configuration=/Volumes/T7-Touch/repos/bitbucket/mac-configurations/MacBookPro16,1-(quaxolotl)/darwin-23.0.0/Sonoma-14
repos_github= builds conferences gbs gf jop d_nursery python reconstructor
bash_scripts=/Volumes/T7-Touch/repos/github/gitlab-bash-scripts
XPC_FLAGS=0x0
stools=/Volumes/T7-Touch/repos/bitbucket/spack-tools
dirDropbox=/spacktivity/mirror
platform=mac
amzn_version=20230
XPC_SERVICE_NAME=0
llnl_ssh=ssh -l topa1 -X
SHLVL=1
HOME=/Users/dantopa
allflags=-Wall -Wextra -Waliasing -Wsurprising -Wimplicit-procedure -Wintrinsics-std -Wfunction-elimination -Wc-bindi
icons=/Volumes/T7-Touch/repos/bitbucket/icons
dscience=dantopa/science-centos:8.5
builds=/Volumes/T7-Touch/repos/github/builds
LOGNAME=dantopa
Wflags=-Wall -Wextra -Waliasing -Wsurprising -Wimplicit-procedure -Wintrinsics-std -Wfunction-elimination -Wc-binding
gflags8=-g -ffpe-trap=denormal,invalid,zero -fbacktrace -Wall -Wextra -Waliasing -Wsurprising -Wimplicit-procedure -W
locker=/Users/dantopa/.info
firmware_v=1715.60.5.0.0 (iBridge: 19.16.10647.0.0,0)
placemat=/Volumes/T7-Touch/repos/bitbucket/placemat
core=/Volumes/T7-Touch/repos/github/gitlab-bash-scripts/core-scripts
vrepos=/Volumes/T7-Touch/repos
gbs=/Volumes/T7-Touch/repos/github/gitlab-bash-scripts
ubuntu_version=22.04
llnl_moniker=topa1
file_docker_log=/Volumes/T7-Touch/repos/github/builds/results-docker/vm-log-book.txt
DISPLAY=/private/tmp/com.apple.launchd.0JarZcoW6h/org.xquartz:0
repo_scripts_docker=/Volumes/T7-Touch/repos/github/builds/scripts-docker
d_nursery=/Volumes/T7-Touch/repos/github/nursery-slide-decks
owner=native
SECURITYSESSIONID=24745
dirPyVirtualEnv=/Users/dantopa/scratch/python-virtual-environments
dirPyTruth=/Users/dantopa/scratch/python-virtual-environments/truth
bash_file=.quaxolotl.sh
_=/usr/bin/env
PS1=\[\ 033[00;35m\]\ u\[\ 033[00m\] @\[\ 033[00;35m\]\ H\[\ 033[00m\] :\[\ 033[00;33m\]\ W\[\ 033[00m\]  $\ 033[00;3
```

2.2 `ldd`

The command **`ldd`** prints shared object dependencies, in this example, for the executable **`bash`**:

```
root@69cb14a32689:/# ldd /bin/bash
        linux-vdso.so.1 (0x00007ffe64317000)
        libtinfo.so.6 => /lib/x86_64-linux-gnu/libtinfo.so.6 (0x00007f842112d000)
        libc.so.6 => /lib/x86_64-linux-gnu/libc.so.6 (0x00007f8420f04000)
        /lib64/ld-linux-x86-64.so.2 (0x00007f84212e3000)
```

Symbolic links (symlinks) are highlighted with blue color.

2.3 `lddconfig`

`lddconfig`: A tool to cnfigure run-time bindings for the dynamic linker. May reside in **`/sbin/lddconfig`**.

2.3.1 Display First Five Current Libraries In The Cache

```
# ldconfig -p | head -5
916 libs found in cache ‘/etc/ld.so.cache’
      libzephyr.so.4 (libc6) => /usr/lib/libzephyr.so.4
      libzbar.so.0 (libc6) => /usr/lib/libzbar.so.0
      libz.so.1 (libc6) => /lib/libz.so.1
      libz.so (libc6) => /usr/lib/libz.so
```

2.3.2 Recursively Display Libraries For Each Directory

```
# ldconfig -v | head
/usr/lib/mesa:
      libGL.so.1 -> libGL.so.1.2
/usr/lib/i686-linux-gnu:
      liblouis.so.2 -> liblouis.so.2.2.0
/usr/lib/alsa-lib:
      libasound_module_ctl_oss.so -> libasound_module_ctl_oss.so
      libasound_module_ctl_bluetooth.so -> libasound_module_ctl_bluetooth.so
      libasound_module_pcm_bluetooth.so -> libasound_module_pcm_bluetooth.so
      libasound_module_pcm_vdownmix.so -> libasound_module_pcm_vdownmix.so
      libasound_module_rate_speexrate.so -> libasound_module_rate_speexrate_medium.so
```

2.4 `locate`

The `locate` command lists files in a prebuilt database of files generated by the `updatedb` command or by a daemon and compressed using incremental encoding.

```
dantopa@92bc4c447e32:/$ locate libc.so.6
/usr/lib/x86_64-linux-gnu/libc.so.6
/usr/lib32/libc.so.6
```

2.5 `lsof`

This command does an `ls` on open files. The example show how to query both a user and a process id (`pid`).

2.5.1 `lsof` on Process ID

The `lsof` command shows open files, here for the bash process with PID = 10932:

```
dantopa@92bc4c447e32:~$ ps
  PID TTY          TIME CMD
10932 pts/1    00:00:00 bash
11152 pts/1    00:00:00 ps
dantopa@92bc4c447e32:~$ lsof -p 10932
COMMAND   PID    USER   FD   TYPE DEVICE SIZE/OFF     NODE NAME
bash    10932 dantopa  cwd    DIR   0,71     4096  6820049 /home/dantopa
bash    10932 dantopa  rtd    DIR   0,71     4096 61653409 /
bash    10932 dantopa  txt    REG   0,71  1396520 62702252 /usr/bin/bash
bash    10932 dantopa  mem    REG  254,1          62702252 /usr/bin/bash (path dev=0,71)
bash    10932 dantopa  mem    REG  254,1          63095938 /usr/lib/x86_64-linux-gnu/libc.so.6 (path dev=0,71)
bash    10932 dantopa  mem    REG  254,1           1190606 /usr/lib/x86_64-linux-gnu/libtinfo.so.6.3 (path dev=0,71)
bash    10932 dantopa  mem    REG  254,1          63095935 /usr/lib/x86_64-linux-gnu/ld-linux-x86-64.so.2 (path dev=0
bash    10932 dantopa    0u   CHR  136,1      0t0        4 /dev/pts/1
bash    10932 dantopa    1u   CHR  136,1      0t0        4 /dev/pts/1
bash    10932 dantopa    2u   CHR  136,1      0t0        4 /dev/pts/1
bash    10932 dantopa  255u   CHR  136,1      0t0        4 /dev/pts/1
```

2.5.2 `lsof` on User

These are open files for user **dantopa**:

```
dantopa@92bc4c447e32:~$ lsof -u dantopa
COMMAND   PID    USER   FD    TYPE DEVICE SIZE/OFF     NODE NAME
bash    10921 dantopa  cwd    DIR   0,71     4096 61653409 /
bash    10921 dantopa  rtd    DIR   0,71     4096 61653409 /
bash    10921 dantopa  txt    REG   0,71  1396520 62702252 /usr/bin/bash
bash    10921 dantopa  mem    REG  254,1          62702252 /usr/bin/bash (path dev=0,71)
bash    10921 dantopa  mem    REG  254,1          63095938 /usr/lib/x86_64-linux-gnu/libc.so.6 (path dev=0,71)
bash    10921 dantopa  mem    REG  254,1           1190606 /usr/lib/x86_64-linux-gnu/libtinfo.so.6.3 (path dev=0,71)
bash    10921 dantopa  mem    REG  254,1          63095935 /usr/lib/x86_64-linux-gnu/ld-linux-x86-64.so.2 (path dev=0
bash    10921 dantopa    0u   CHR  136,0      0t0        3 /dev/pts/0
bash    10921 dantopa    1u   CHR  136,0      0t0        3 /dev/pts/0
bash    10921 dantopa    2u   CHR  136,0      0t0        3 /dev/pts/0
bash    10921 dantopa  255u   CHR  136,0      0t0        3 /dev/pts/0
bash    10932 dantopa  cwd    DIR   0,33      704     1572 /repos/github/vault-fortran/Xmodern-fortran/tau/apex
bash    10932 dantopa  rtd    DIR   0,71     4096 61653409 /
bash    10932 dantopa  txt    REG   0,71  1396520 62702252 /usr/bin/bash
bash    10932 dantopa  mem    REG  254,1          62702252 /usr/bin/bash (path dev=0,71)
bash    10932 dantopa  mem    REG  254,1          63095938 /usr/lib/x86_64-linux-gnu/libc.so.6 (path dev=0,71)
bash    10932 dantopa  mem    REG  254,1           1190606 /usr/lib/x86_64-linux-gnu/libtinfo.so.6.3 (path dev=0,71)
bash    10932 dantopa  mem    REG  254,1          63095935 /usr/lib/x86_64-linux-gnu/ld-linux-x86-64.so.2 (path dev=0
bash    10932 dantopa    0u   CHR  136,1      0t0        4 /dev/pts/1
bash    10932 dantopa    1u   CHR  136,1      0t0        4 /dev/pts/1
bash    10932 dantopa    2u   CHR  136,1      0t0        4 /dev/pts/1
bash    10932 dantopa  255u   CHR  136,1      0t0        4 /dev/pts/1
lsof    11139 dantopa  cwd    DIR   0,33      704     1572 /repos/github/vault-fortran/Xmodern-fortran/tau/apex
lsof    11139 dantopa  rtd    DIR   0,71     4096 61653409 /
lsof    11139 dantopa  txt    REG   0,71   167544   709329 /usr/bin/lsof
lsof    11139 dantopa  mem    REG  254,1            709329 /usr/bin/lsof (path dev=0,71)
lsof    11139 dantopa  mem    REG  254,1          63095951 /usr/lib/x86_64-linux-gnu/libresolv.so.2 (path dev=0,71)
lsof    11139 dantopa  mem    REG  254,1           1190531 /usr/lib/x86_64-linux-gnu/libkeyutils.so.1.9 (path dev=0,7
lsof    11139 dantopa  mem    REG  254,1          63096020 /usr/lib/x86_64-linux-gnu/libkrb5support.so.0.1 (path dev=
lsof    11139 dantopa  mem    REG  254,1          63096026 /usr/lib/x86_64-linux-gnu/libcom_err.so.2.1 (path dev=0,71
lsof    11139 dantopa  mem    REG  254,1          63096018 /usr/lib/x86_64-linux-gnu/libk5crypto.so.3.1 (path dev=0,7
lsof    11139 dantopa  mem    REG  254,1          63096022 /usr/lib/x86_64-linux-gnu/libkrb5.so.3.3 (path dev=0,71)
lsof    11139 dantopa  mem    REG  254,1           1190578 /usr/lib/x86_64-linux-gnu/libpcre2-8.so.0.10.4 (path dev=0
lsof    11139 dantopa  mem    REG  254,1          63096024 /usr/lib/x86_64-linux-gnu/libgssapi_krb5.so.2.2 (path dev=
lsof    11139 dantopa  mem    REG  254,1          63095938 /usr/lib/x86_64-linux-gnu/libc.so.6 (path dev=0,71)
lsof    11139 dantopa  mem    REG  254,1           1190588 /usr/lib/x86_64-linux-gnu/libselinux.so.1 (path dev=0,71)
lsof    11139 dantopa  mem    REG  254,1           1190608 /usr/lib/x86_64-linux-gnu/libtirpc.so.3.0.0 (path dev=0,71
lsof    11139 dantopa  mem    REG  254,1          63095935 /usr/lib/x86_64-linux-gnu/ld-linux-x86-64.so.2 (path dev=0
lsof    11139 dantopa    0u   CHR  136,1      0t0        4 /dev/pts/1
lsof    11139 dantopa    1u   CHR  136,1      0t0        4 /dev/pts/1
lsof    11139 dantopa    2u   CHR  136,1      0t0        4 /dev/pts/1
lsof    11139 dantopa    3r   DIR   0,74        0        1 /proc
lsof    11139 dantopa    4r   DIR   0,74        7   123326 /proc/11139/fd
lsof    11139 dantopa    5w  FIFO   0,11      0t0   123331 pipe
lsof    11139 dantopa    6r  FIFO   0,11      0t0   123332 pipe
lsof    11140 dantopa  cwd    DIR   0,33      704     1572 /repos/github/vault-fortran/Xmodern-fortran/tau/apex
lsof    11140 dantopa  rtd    DIR   0,71     4096 61653409 /
lsof    11140 dantopa  txt    REG   0,71   167544   709329 /usr/bin/lsof
lsof    11140 dantopa  mem    REG  254,1            709329 /usr/bin/lsof (path dev=0,71)
lsof    11140 dantopa  mem    REG  254,1          63095951 /usr/lib/x86_64-linux-gnu/libresolv.so.2 (path dev=0,71)
lsof    11140 dantopa  mem    REG  254,1           1190531 /usr/lib/x86_64-linux-gnu/libkeyutils.so.1.9 (path dev=0,7
lsof    11140 dantopa  mem    REG  254,1          63096020 /usr/lib/x86_64-linux-gnu/libkrb5support.so.0.1 (path dev=
lsof    11140 dantopa  mem    REG  254,1          63096026 /usr/lib/x86_64-linux-gnu/libcom_err.so.2.1 (path dev=0,71
lsof    11140 dantopa  mem    REG  254,1          63096018 /usr/lib/x86_64-linux-gnu/libk5crypto.so.3.1 (path dev=0,7
lsof    11140 dantopa  mem    REG  254,1          63096022 /usr/lib/x86_64-linux-gnu/libkrb5.so.3.3 (path dev=0,71)
lsof    11140 dantopa  mem    REG  254,1           1190578 /usr/lib/x86_64-linux-gnu/libpcre2-8.so.0.10.4 (path dev=0
lsof    11140 dantopa  mem    REG  254,1          63096024 /usr/lib/x86_64-linux-gnu/libgssapi_krb5.so.2.2 (path dev=
lsof    11140 dantopa  mem    REG  254,1          63095938 /usr/lib/x86_64-linux-gnu/libc.so.6 (path dev=0,71)
lsof    11140 dantopa  mem    REG  254,1           1190588 /usr/lib/x86_64-linux-gnu/libselinux.so.1 (path dev=0,71)
lsof    11140 dantopa  mem    REG  254,1           1190608 /usr/lib/x86_64-linux-gnu/libtirpc.so.3.0.0 (path dev=0,71
lsof    11140 dantopa  mem    REG  254,1          63095935 /usr/lib/x86_64-linux-gnu/ld-linux-x86-64.so.2 (path dev=0
lsof    11140 dantopa    4r  FIFO   0,11      0t0   123331 pipe
lsof    11140 dantopa    7w  FIFO   0,11      0t0   123332 pipe
```

2.6 objdump

The **objdump** command shows dependent shared objects, typically libraries. Two versions of the shared library for the GNU standard C library – one 32 bit, the other 64 bit – are located.

```
dantopa@92bc4c447e32:/$ locate libc.so.6
/usr/lib/x86_64-linux-gnu/libc.so.6
/usr/lib32/libc.so.6
```

2.7 readelf

The **readelf** command displays information about ELF files, or Executable and Linkable Format files which are a standard file format for executable files, object code, shared libraries, and core dumps.[1] This example lists the header file for the command **bash**.

```
dantopa@92bc4c447e32:~$ file /bin/bash
/bin/bash: ELF 64-bit LSB pie executable, x86-64, version 1 (SYSV), dynamically linked, interpreter /lib64/ld-linux-x
BuildID[sha1]=7a6408ba82a2d86dd98f1f75ac8edcb695f6fd60, for GNU/Linux 3.2.0, stripped
dantopa@92bc4c447e32:~$ readelf -h /bin/bash
ELF Header:
  Magic:   7f 45 4c 46 02 01 01 00 00 00 00 00 00 00 00 00
  Class:                             ELF64
  Data:                              2's complement, little endian
  Version:                           1 (current)
  OS/ABI:                            UNIX - System V
  ABI Version:                       0
  Type:                              DYN (Position-Independent Executable file)
  Machine:                           Advanced Micro Devices X86-64
  Version:                           0x1
  Entry point address:               0x32ef0
  Start of program headers:          64 (bytes into file)
  Start of section headers:          1394600 (bytes into file)
  Flags:                             0x0
  Size of this header:               64 (bytes)
  Size of program headers:           56 (bytes)
  Number of program headers:         13
  Size of section headers:           64 (bytes)
  Number of section headers:         30
  Section header string table index: 29
```

2.8 nm

The **nm** command shows dependent shared objects and executables;

[1] For an ELF cheatsheet see https://gist.github.com/x0nu11byt3/bcb35c3de461e5fb66173071a2379779.

2.8.1 Find Headers Only

```
dantopa@Quaxolotl.local:z2-debug $ nm z2 | grep header
0000000100000000 T __mh_execute_header
```

2.8.2 Find Everything

```
dantopa@Quaxolotl.local:z2-debug $ nm z2
000000010000323c T __Z6moveupPii
000000010000346f T __Z6updatedPP7__sFILE
00000001000032cd T __Z8movedownPii
000000010000335d T __Z9coldstartv
0000000100003e98 s __ZNSt8__detail30__integer_to_chars_is_unsignedIjEE
0000000100003e99 s __ZNSt8__detail30__integer_to_chars_is_unsignedImEE
0000000100003e9a s __ZNSt8__detail30__integer_to_chars_is_unsignedIyEE
0000000100000000 T __mh_execute_header
                 U _drand48
                 U _exit
                 U _exp
                 U _fclose
                 U _fopen
                 U _getcwd
0000000100008000 S _lnk
0000000100003ae8 T _main
                 U _perror
                 U _printf
                 U _srand48
                 U mcount
```

2.9 strace

The `strace` command reveals how an executable interactis with the operating system.

2.9.1 Trace System From HelloWorld

```
[root@nickdev ~]$ strace ./hello_world
execve("./hello_world", ["./hello_world"], [/* 50 vars */]) = 0
brk(0)                                  = 0xa7e000
access("/etc/ld.so.nohwcap", F_OK)      = -1 ENOENT (No such file or directory)
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f7583380000
access("/etc/ld.so.preload", R_OK)      = -1 ENOENT (No such file or directory)
open("/etc/ld.so.cache", O_RDONLY)      = 3
fstat(3, st_mode=S_IFREG|0644, st_size=77737, ...) = 0
mmap(NULL, 77737, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f758336d000
close(3)                                = 0
access("/etc/ld.so.nohwcap", F_OK)      = -1 ENOENT (No such file or directory)
open("/lib/libc.so.6", O_RDONLY)        = 3
read(3, "\ 177ELF\ 2\ 1\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 3\ 0>\ 0\ 1\ 0\ 0\ 0‘\ 355\ 1\ 0\ 0\ 0\ 0"..., 832) = 832
fstat(3, st_mode=S_IFREG|0755, st_size=1432968, ...) = 0
mmap(NULL, 3541032, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f7582e04000
mprotect(0x7f7582f5c000, 2093056, PROT_NONE) = 0
mmap(0x7f758315b000, 20480, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x157000) = 0x7f758315b000
mmap(0x7f7583160000, 18472, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f7583160000
close(3)                                = 0
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f758336c000
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f758336b000
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f758336a000
arch_prctl(ARCH_SET_FS, 0x7f758336b700) = 0
```

```
mprotect(0x7f758315b000, 16384, PROT_READ) = 0
mprotect(0x7f7583382000, 4096, PROT_READ) = 0
munmap(0x7f758336d000, 77737)           = 0
fstat(1, st_mode=S_IFCHR|0600, st_rdev=makedev(136, 6), ...) = 0
mmap(NULL, 4096, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f758337f000
write(1, "Hello, world\ n", 13Hello, world
)          = 13
exit_group(0)                           = ?
```

2.9.2 Trace System Calls To A Given Path

```
root@169e8b2c1ae3:/# strace -P /etc/ld.so.cache ls /dev/null
openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
newfstatat(3, "", st_mode=S_IFREG|0644, st_size=135191, ..., AT_EMPTY_PATH) = 0
mmap(NULL, 135191, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f03bba95000
close(3)                                = 0
/dev/null
+++ exited with 0 +++
```

2.9.3 Inventory time, calls, and errors for every system call

```
root@169e8b2c1ae3:/# strace -c ls > /dev/null
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
 71.76    0.013546        6773         2           getdents64
  7.85    0.001482         247         6           openat
  4.88    0.000922         922         1           execve
  4.44    0.000839          49        17           mmap
  1.84    0.000347          43         8           close
  1.48    0.000279          39         7           mprotect
  1.40    0.000265          37         7           newfstatat
  1.26    0.000237          47         5           read
  0.94    0.000178          44         4           pread64
  0.77    0.000145          48         3           brk
  0.57    0.000108          36         3         3 ioctl
  0.49    0.000092          46         2         2 statfs
  0.47    0.000088          44         2         2 access
  0.34    0.000065          32         2         1 arch_prctl
  0.34    0.000065          65         1           getrandom
  0.32    0.000061          61         1           munmap
  0.18    0.000034          34         1           rseq
  0.17    0.000032          32         1           set_robust_list
  0.16    0.000031          31         1           write
  0.16    0.000031          31         1           set_tid_address
  0.16    0.000031          31         1           prlimit64
------ ----------- ----------- --------- --------- ----------------
100.00    0.018878         248        76         8 total
```

2.9.4 Identify Information Associated With File Descriptors

```
root@169e8b2c1ae3:/# strace -yy cat /dev/null
execve("/usr/bin/cat", ["cat", "/dev/null"], 0x7fffb8b235d0 /* 10 vars */) = 0
brk(NULL)                               = 0x5611c6a38000
arch_prctl(0x3001 /* ARCH_??? */, 0x7ffeede990c0) = -1 EINVAL (Invalid argument)
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f5c648b8000
access("/etc/ld.so.preload", R_OK)      = -1 ENOENT (No such file or directory)
openat(AT_FDCWD</>, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3</etc/ld.so.cache>
newfstatat(3</etc/ld.so.cache>, "", st_mode=S_IFREG|0644, st_size=135191, ..., AT_EMPTY_PATH) = 0
```

```
mmap(NULL, 135191, PROT_READ, MAP_PRIVATE, 3</etc/ld.so.cache>, 0) = 0x7f5c64896000
close(3</etc/ld.so.cache>)             = 0
openat(AT_FDCWD</>, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3</usr/lib/x86_64-linux-gnu/libc.so.6>
read(3</usr/lib/x86_64-linux-gnu/libc.so.6>, "\ 177ELF\2\1\1\3\0\0\0\0\0\0\0\0\3\0>\0\1\0\0\0P\237\2\0\0\0\0\0"..., 8
pread64(3</usr/lib/x86_64-linux-gnu/libc.so.6>, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 7
pread64(3</usr/lib/x86_64-linux-gnu/libc.so.6>, "\4\0\0\0 \0\0\0\5\0\0\0GNU\0\2\0\0\300\4\0\0\0\3\0\0\0\0\0\0\0"...,
pread64(3</usr/lib/x86_64-linux-gnu/libc.so.6>, "\4\0\0\0\24\0\0\0\3\0\0\0GNU\0I\17\357\204\3$\ f\221\2039x\324\224\3
newfstatat(3</usr/lib/x86_64-linux-gnu/libc.so.6>, "", st_mode=S_IFREG|0755, st_size=2220400, ..., AT_EMPTY_PATH) = 0
pread64(3</usr/lib/x86_64-linux-gnu/libc.so.6>, "\6\0\0\0\4\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0@\0\0\0\0\0\0\0"..., 7
mmap(NULL, 2264656, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3</usr/lib/x86_64-linux-gnu/libc.so.6>, 0) = 0x7f5c6466d000
mprotect(0x7f5c64695000, 2023424, PROT_NONE) = 0
mmap(0x7f5c64695000, 1658880, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3</usr/lib/x86_64-linux-gnu/l
mmap(0x7f5c6482a000, 360448, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3</usr/lib/x86_64-linux-gnu/libc.so.6>,
mmap(0x7f5c64883000, 24576, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3</usr/lib/x86_64-linux-gnu/li
mmap(0x7f5c64889000, 52816, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f5c64889000
close(3</usr/lib/x86_64-linux-gnu/libc.so.6>) = 0
mmap(NULL, 12288, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f5c6466a000
arch_prctl(ARCH_SET_FS, 0x7f5c6466a740) = 0
set_tid_address(0x7f5c6466aa10)        = 23663
set_robust_list(0x7f5c6466aa20, 24)    = 0
rseq(0x7f5c6466b0e0, 0x20, 0, 0x53053053) = 0
mprotect(0x7f5c64883000, 16384, PROT_READ) = 0
mprotect(0x5611c4bde000, 4096, PROT_READ) = 0
mprotect(0x7f5c648f2000, 8192, PROT_READ) = 0
prlimit64(0, RLIMIT_STACK, NULL, rlim_cur=8192*1024, rlim_max=RLIM64_INFINITY) = 0
munmap(0x7f5c64896000, 135191)         = 0
getrandom("\\ x7e\ x74\ x62\ xbc\ x66\ x05\ x81\ xf8", 8, GRND_NONBLOCK) = 8
brk(NULL)                              = 0x5611c6a38000
brk(0x5611c6a59000)                    = 0x5611c6a59000
newfstatat(1</dev/pts/0<char 136:0>>, "", st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0), ..., AT_EMPTY_PATH) = 0
openat(AT_FDCWD</>, "/dev/null", O_RDONLY) = 3</dev/null<char 1:3>>
newfstatat(3</dev/null<char 1:3>>, "", st_mode=S_IFCHR|0666, st_rdev=makedev(0x1, 0x3), ..., AT_EMPTY_PATH) = 0
fadvise64(3</dev/null<char 1:3>>, 0, 0, POSIX_FADV_SEQUENTIAL) = 0
mmap(NULL, 139264, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f5c64896000
read(3</dev/null<char 1:3>>, "", 131072) = 0
munmap(0x7f5c64896000, 139264)         = 0
close(3</dev/null<char 1:3>>)          = 0
close(1</dev/pts/0<char 136:0>>)       = 0
close(2</dev/pts/0<char 136:0>>)       = 0
exit_group(0)                          = ?
+++ exited with 0 +++
```

2.10 strings

Print the sequences of printable characters in files using **strings**.

2.10.1 Applied To Compiled Object File

```
dantopa@Quaxolotl.local:vv $ strings -a m-precision-definitions.o
GNU Fortran2008 12.1.0 -fPIC -feliminate-unused-debug-symbols -mmacosx-version-min=12.0.0 -mtune=core2 -g -Og -fno-re
/Volumes/T7-Touch/repos/github/f/dtra/vv
aint
integer(kind=4)
ascii
kinda
lint
sint
zint
```

```
integer(kind=4)
m-precision-definitions.f08
```

2.10.2 Applied To Object Class

```
dantopa@Quaxolotl.local:bravo $ strings m-cl-soln-basic.o
Error allocating %lu bytes
In file 'm-cl-soln-basic.f08', around line 99
Index '%ld' of dimension 1 of array 'sizes' above upper bound of %ld
At line 98 of file m-cl-soln-basic.f08
Loop iterates infinitely
Index '%ld' of dimension 1 of array 'strides' below lower bound of %ld
Index '%ld' of dimension 1 of array 'strides' above upper bound of %ld
Index '%ld' of dimension 1 of array 'sizes' below lower bound of %ld
Recursive call to nonrecursive procedure 'solnscalingparameter_sub'
At line 69 of file m-cl-soln-basic.f08
m-cl-soln-basic.f08
Array bound mismatch for dimension 1 of array 'u' (%ld/%ld)
At line 85 of file m-cl-soln-basic.f08
Recursive call to nonrecursive procedure 'solncomputesigma_sub'
At line 53 of file m-cl-soln-basic.f08
Array bound mismatch for dimension 1 of array 'me' (%ld/%ld)
At line 60 of file m-cl-soln-basic.f08
Array bound mismatch for dimension 1 of array 'measurements' (%ld/%ld)
At line 61 of file m-cl-soln-basic.f08
Recursive call to nonrecursive procedure 'solnbasic_sub'
At line 33 of file m-cl-soln-basic.f08
Allocatable actual argument 'measurements' is not allocated
At line 38 of file m-cl-soln-basic.f08
Potential error: || u || =
Subroutine: solnScalingParameter_sub
Module:     mClassSolutionBasic
Small size may magnifiy errors in solution parameter a
GNU Fortran2008 13.2.0 -fPIC -feliminate-unused-debug-symbols -mmacosx-version-min=14.0.0 -mtune=core2 -g -Og -fno-re
m-cl-soln-basic.f08
/Volumes/T7-Touch/repos/github/f/projects/fireball/bravo
sigma
count
phimin
phi2min
sigmasc
residualerror
upsilon
alloc
real(kind=8)
toolkitallocation
requestedgb
alloc_status
sizeelementbits
numelements
numrows
numcols
alloc_message
mykind
integer(kind=4)
__def_init_mclasssolutionbasic_Solnbasic
__mclasssolutionbasic_MOD___def_init_mclasssolutionbasic_Solnbasic
integer(kind=8)
```

```
__vtype_mclasssolutionbasic_Solnbasic
_hash
_size
_extends
_def_init
_copy
_final
_deallocate
solncomputesigma
solnscalingparameter
__class_mclasssolutionbasic_Solnbasic_t
_data
_vptr
data
maxradius
time
radius
alloc
__vtab_mclasssolutionbasic_Solnbasic
__mclasssolutionbasic_MOD___vtab_mclasssolutionbasic_Solnbasic
logical(kind=4)
solnbasic_sub
!#__mclasssolutionbasic_MOD_solnbasic_sub
_descriptor
solncomputesigma_sub
5*__mclasssolutionbasic_MOD_solncomputesigma_sub
solnscalingparameter_sub
E.__mclasssolutionbasic_MOD_solnscalingparameter_sub
normu
__copy_mclasssolutionbasic_Solnbasic
__mclasssolutionbasic_MOD___copy_mclasssolutionbasic_Solnbasic
__final_mclasssolutionbasic_Solnbasic
__mclasssolutionbasic_MOD___final_mclasssolutionbasic_Solnbasic
array
byte_stride
fini_coarray
idx2
ignore
is_contiguous
nelem
offset
ptr2
sizes
strides
__result___final_mclasssoluti
logical(kind=1)
?
 4
__def_init_mclasssolutionbasic_Solnbasic
__vtab_mclasssolutionbasic_Solnbasic
__def_init_mclasssolutionbasic_Solnbasic
__vtab_mclasssolutionbasic_Solnbasic
solnbasic_sub
solncomputesigma_sub
solnscalingparameter_sub
__copy_mclasssolutionbasic_Solnbasic
__final_mclasssolutionbasic_Solnbasic
real(kind=8)
```

```
integer(kind=4)
mclasssolutionbasic.toolkitallocation
mclasssolutionbasic.solnbasic
integer(kind=8)
mclasssolutionbasic.__class_mclasssolutionbasic_Solnbasic_t
mclasssolutionbasic.data
mclasssolutionbasic.__vtype_mclasssolutionbasic_Solnbasic
logical(kind=4)
logical(kind=1)
m-cl-soln-basic.f08
measurements
descriptor
solnbasic
```

2.11 `gdb`

The application **`gdb`** is an open-source code debugger. When codes are compiled with debug symbols (e.g. `gcc -d ...`) the debugger is a powerful. But even for codes compiled without debug symbols, **`gdb`** provides helpful information. For example, the following memory error is traced to the Qt library.

```
dantopa@dtopa-latitude-5491:bin $ gdb -ex bt ./MMViz_4.1.12 core
GNU gdb (Ubuntu 9.0.90.20200105-0ubuntu1) 9.0.90.20200105-git
Copyright (C) 2019 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.
Type "show copying" and "show warranty" for details.
This GDB was configured as "x86_64-linux-gnu".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
    <http://www.gnu.org/software/gdb/documentation/>.

For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from ./MMViz_4.1.12...
(No debugging symbols found in ./MMViz_4.1.12)
[New LWP 1885649]
[New LWP 1885710]
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib/x86_64-linux-gnu/libthread_db.so.1".
Core was generated by `./MMViz_4.1.12'.
Program terminated with signal SIGSEGV, Segmentation fault.
--Type <RET> for more, q to quit, c to continue without paging--c
#0  0x000000000042730b in
       vector_and_utility_module_mp_real_vector_norm_.A ()
[Current thread is 1 (Thread 0x7f4673884e00 (LWP 1885649))]
#0  0x000000000042730b in
       vector_and_utility_module_mp_real_vector_norm_.A ()
#1  0x0000000000545b78 in
       sie_geometry_module_mp_sie_geometry_tri_compute_.A ()
#2  0x0000000000643b1d in
       mmviz_geometry_module_mp_readgeometry_.A ()
#3  0x0000000000746e37 in
       MMViz::loadFile(QString const&) ()
#4  0x0000000000757004 in
       MMViz::qt_metacall(QMetaObject::Call, int, void**) ()
#5  0x00007f46754c8f3b in
```

```
       QMetaObject::activate(QObject*, int, int, void**) ()
       from /home/dantopa/Dropbox/2nd-generation/RCS-project/4.1.12/Linux64/bin/libQtCore.so.4
#6  0x00000000007567c4 in
       currentUI::loadFile(QString) ()
#7  0x00000000006a9dbd in
       currentUI::createGeometry() ()
#8  0x0000000000756428 in
       currentUI::qt_metacall(QMetaObject::Call, int, void**) ()
#9  0x00007f46754c8f3b in
       QMetaObject::activate(QObject*, int, int, void**) ()
       from /home/dantopa/Dropbox/2nd-generation/RCS-project/4.1.12/Linux64/bin/libQtCore.so.4
#10 0x00007f46760b3fc9 in
       QAbstractButtonPrivate::click() ()
       from /home/dantopa/Dropbox/2nd-generation/RCS-project/4.1.12/Linux64/bin/libQtGui.so.4
#11 0x00007f46760b418b in
       QAbstractButton::mouseReleaseEvent(QMouseEvent*) ()
       from /home/dantopa/Dropbox/2nd-generation/RCS-project/4.1.12/Linux64/bin/libQtGui.so.4
#12 0x00007f4675e9fc2f in
       QWidget::event(QEvent*) ()
       from /home/dantopa/Dropbox/2nd-generation/RCS-project/4.1.12/Linux64/bin/libQtGui.so.4
#13 0x00007f4675e6d599 in
       QApplicationPrivate::notify_helper(QObject*, QEvent*) ()
       from /home/dantopa/Dropbox/2nd-generation/RCS-project/4.1.12/Linux64/bin/libQtGui.so.4
#14 0x00007f4675e6cef8 in
       QApplication::notify(QObject*, QEvent*) ()
       from /home/dantopa/Dropbox/2nd-generation/RCS-project/4.1.12/Linux64/bin/libQtGui.so.4
#15 0x00007f4675eb4095 in
       QETWidget::translateMouseEvent(_XEvent const*) ()
       from /home/dantopa/Dropbox/2nd-generation/RCS-project/4.1.12/Linux64/bin/libQtGui.so.4
#16 0x00007f4675ead60f in
       QApplication::x11ProcessEvent(_XEvent*) ()
       from /home/dantopa/Dropbox/2nd-generation/RCS-project/4.1.12/Linux64/bin/libQtGui.so.4
#17 0x00007f4675ec5e45 in
       QEventDispatcherX11::processEvents(QFlags<QEventLoop::ProcessEventsFlag>) ()
       from /home/dantopa/Dropbox/2nd-generation/RCS-project/4.1.12/Linux64/bin/libQtGui.so.4
#18 0x00007f46754b5be7 in
       QEventLoop::processEvents(QFlags<QEventLoop::ProcessEventsFlag>) ()
       from /home/dantopa/Dropbox/2nd-generation/RCS-project/4.1.12/Linux64/bin/libQtCore.so.4
#19 0x00007f46754b5d17 in
       QEventLoop::exec(QFlags<QEventLoop::ProcessEventsFlag>) ()
       from /home/dantopa/Dropbox/2nd-generation/RCS-project/4.1.12/Linux64/bin/libQtCore.so.4
#20 0x00007f46754b92cd in
       QCoreApplication::exec() ()
       from /home/dantopa/Dropbox/2nd-generation/RCS-project/4.1.12/Linux64/bin/libQtCore.so.4
#21 0x0000000000720479
       in main ()
```

3 Manual Pages

3.1 env: Show ENVIRONMENT variables.

```
NAME
       env - run a program in a modified environment
SYNOPSIS
       env [OPTION]... [-] [NAME=VALUE]... [COMMAND [ARG]...]
DESCRIPTION
       Set each NAME to VALUE in the environment and run COMMAND.

       Mandatory arguments to long options are mandatory for short
       options too.
       -a, --argv0=ARG
              pass ARG as the zeroth argument of COMMAND

       -i, --ignore-environment
              start with an empty environment

       -0, --null
              end each output line with NUL, not newline

       -u, --unset=NAME
              remove variable from the environment

       -C, --chdir=DIR
              change working directory to DIR

       -S, --split-string=S
              process and split S into separate arguments; used to pass
              multiple arguments on shebang lines

       --block-signal[=SIG]
              block delivery of SIG signal(s) to COMMAND

       --default-signal[=SIG]
              reset handling of SIG signal(s) to the default

       --ignore-signal[=SIG]
              set handling of SIG signal(s) to do nothing

       --list-signal-handling
              list non default signal handling to stderr

       -v, --debug
              print verbose information for each processing step

       --help display this help and exit

       --version
              output version information and exit

       A mere - implies -i.  If no COMMAND, print the resulting
       environment.

       SIG may be a signal name like 'PIPE', or a signal number like
       '13'.  Without SIG, all known signals are included.  Multiple
       signals can be comma-separated.  An empty SIG argument is a
       no-op.

   Exit status:
       125    if the env command itself fails

       126    if COMMAND is found but cannot be invoked

       127    if COMMAND cannot be found

       -      the exit status of COMMAND otherwise
OPTIONS
   -S/--split-string usage in scripts
       The -S option allows specifying multiple parameters in a script.
       Running a script named 1.pl containing the following first line:

              #!/usr/bin/env -S perl -w -T
              ...

       Will execute perl -w -T 1.pl .

       Without the '-S' parameter the script will likely fail with:

              /usr/bin/env: 'perl␣-w␣-T': No such file or directory

       See the full documentation for more details.

   --default-signal[=SIG] usage
       This option allows setting a signal handler to its default
       action, which is not possible using the traditional shell trap
       command.  The following example ensures that seq will be
       terminated by SIGPIPE no matter how this signal is being handled
       in the process invoking the command.

              sh -c 'env␣--default-signal=PIPE␣seq␣inf␣|␣head␣-n1'
NOTES
       POSIX's␣exec(3p)␣pages␣says:
␣␣␣␣␣␣␣␣␣␣␣␣␣␣"many␣existing␣applications␣wrongly␣assume␣that␣they␣start
␣␣␣␣␣␣␣␣␣␣␣␣␣␣with␣certain␣signals␣set␣to␣the␣default␣action␣and/or
␣␣␣␣␣␣␣␣␣␣␣␣␣␣unblocked....␣Therefore,␣it␣is␣best␣not␣to␣block␣or␣ignore
␣␣␣␣␣␣␣␣␣␣␣␣␣␣signals␣across␣execs␣without␣explicit␣reason␣to␣do␣so,␣and
␣␣␣␣␣␣␣␣␣␣␣␣␣␣especially␣not␣to␣block␣signals␣across␣execs␣of␣arbitrary
␣␣␣␣␣␣␣␣␣␣␣␣␣␣(not␣closely␣cooperating)␣programs."
AUTHOR
␣␣␣␣␣␣␣Written␣by␣Richard␣Mlynarik,␣David␣MacKenzie,␣and␣Assaf␣Gordon.
REPORTING␣BUGS
␣␣␣␣␣␣␣GNU␣coreutils␣online␣help:
```

```
␣␣␣␣␣␣␣<https://www.gnu.org/software/coreutils/>
␣␣␣␣␣␣␣Report␣any␣translation␣bugs␣to
␣␣␣␣␣␣␣<https://translationproject.org/team/>
COPYRIGHT
␣␣␣␣␣␣␣Copyright␣(C)␣2024␣Free␣Software␣Foundation,␣Inc.␣␣License␣GPLv3+:
␣␣␣␣␣␣␣GNU␣GPL␣version␣3␣or␣later␣<https://gnu.org/licenses/gpl.html>.
␣␣␣␣␣␣␣This␣is␣free␣software:␣you␣are␣free␣to␣change␣and␣redistribute
␣␣␣␣␣␣␣it.␣␣There␣is␣NO␣WARRANTY,␣to␣the␣extent␣permitted␣by␣law.
SEE␣ALSO
␣␣␣␣␣␣␣sigaction(2),␣sigprocmask(2),␣signal(7)

␣␣␣␣␣␣␣Full␣documentation␣<https://www.gnu.org/software/coreutils/env>
␣␣␣␣␣␣␣or␣available␣locally␣via:␣info␣'(coreutils) env invocation'
COLOPHON
␣␣␣␣␣␣␣This␣page␣is␣part␣of␣the␣coreutils␣(basic␣file,␣shell␣and␣text
␣␣␣␣␣␣␣manipulation␣utilities)␣project.␣␣Information␣about␣the␣project
␣␣␣␣␣␣␣can␣be␣found␣at␣http://www.gnu.org/software/coreutils/.␣␣If␣you
␣␣␣␣␣␣␣have␣a␣bug␣report␣for␣this␣manual␣page,␣see
␣␣␣␣␣␣␣http://www.gnu.org/software/coreutils/.␣␣This␣page␣was␣obtained
␣␣␣␣␣␣␣from␣the␣tarball␣coreutils-9.5.tar.xz␣fetched␣from
␣␣␣␣␣␣␣http://ftp.gnu.org/gnu/coreutils/␣on␣2024-06-14.␣␣If␣you
␣␣␣␣␣␣␣discover␣any␣rendering␣problems␣in␣this␣HTML␣version␣of␣the␣page,
␣␣␣␣␣␣␣or␣you␣believe␣there␣is␣a␣better␣or␣more␣up-to-date␣source␣for
␣␣␣␣␣␣␣the␣page,␣or␣you␣have␣corrections␣or␣improvements␣to␣the
␣␣␣␣␣␣␣information␣in␣this␣COLOPHON␣(which␣is␣not␣part␣of␣the␣original
␣␣␣␣␣␣␣manual␣page),␣send␣a␣mail␣to␣man-pages@man7.org

GNU␣coreutils␣9.5␣␣␣␣␣␣␣␣␣␣␣␣␣␣March␣2024␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣ENV(1)
```

3.2 ldd: Print Shared Object Dependencies

```
NAME
       ldd - print shared object dependencies
SYNOPSIS
       ldd [option]... file...
DESCRIPTION
       ldd prints the shared objects (shared libraries) required by each
       program or shared object specified on the command line.  An
       example of its use and output is the following:

           $ ldd /bin/ls
               linux-vdso.so.1 (0x00007ffcc3563000)
               libselinux.so.1 => /lib64/libselinux.so.1 (0x00007f87e5459000)
               libcap.so.2 => /lib64/libcap.so.2 (0x00007f87e5254000)
               libc.so.6 => /lib64/libc.so.6 (0x00007f87e4e92000)
               libpcre.so.1 => /lib64/libpcre.so.1 (0x00007f87e4c22000)
               libdl.so.2 => /lib64/libdl.so.2 (0x00007f87e4a1e000)
               /lib64/ld-linux-x86-64.so.2 (0x00005574bf12e000)
               libattr.so.1 => /lib64/libattr.so.1 (0x00007f87e4817000)
               libpthread.so.0 => /lib64/libpthread.so.0 (0x00007f87e45fa000)

       In the usual case, ldd invokes the standard dynamic linker (see
       ld.so(8)) with the LD_TRACE_LOADED_OBJECTS environment variable
       set to 1.  This causes the dynamic linker to inspect the
       program's␣dynamic␣dependencies,␣and␣find␣(according␣to␣the␣rules
␣␣␣␣␣␣␣described␣in␣ld.so(8))␣and␣load␣the␣objects␣that␣satisfy␣those
␣␣␣␣␣␣␣dependencies.␣␣For␣each␣dependency,␣ldd␣displays␣the␣location␣of
␣␣␣␣␣␣␣the␣matching␣object␣and␣the␣(hexadecimal)␣address␣at␣which␣it␣is
␣␣␣␣␣␣␣loaded.␣␣(The␣linux-vdso␣and␣ld-linux␣shared␣dependencies␣are
␣␣␣␣␣␣␣special;␣see␣vdso(7)␣and␣ld.so(8).)

␣␣␣Security
␣␣␣␣␣␣␣Be␣aware␣that␣in␣some␣circumstances␣(e.g.,␣where␣the␣program
␣␣␣␣␣␣␣specifies␣an␣ELF␣interpreter␣other␣than␣ld-linux.so),␣some
␣␣␣␣␣␣␣versions␣of␣ldd␣may␣attempt␣to␣obtain␣the␣dependency␣information
␣␣␣␣␣␣␣by␣attempting␣to␣directly␣execute␣the␣program,␣which␣may␣lead␣to
␣␣␣␣␣␣␣the␣execution␣of␣whatever␣code␣is␣defined␣in␣the␣program's ELF
       interpreter, and perhaps to execution of the program itself.
       (Before glibc 2.27, the upstream ldd implementation did this for
       example, although most distributions provided a modified version
       that did not.)

       Thus, you should never employ ldd on an untrusted executable,
       since this may result in the execution of arbitrary code.  A
       safer alternative when dealing with untrusted executables is:

           $ objdump -p /path/to/program | grep NEEDED

       Note, however, that this alternative shows only the direct
       dependencies of the executable, while ldd shows the entire
       dependency tree of the executable.
OPTIONS
       --version
              Print the version number of ldd.

       --verbose
       -v     Print all information, including, for example, symbol
              versioning information.
       --unused
       -u     Print unused direct dependencies.  (Since glibc 2.3.4.)

       --data-relocs
       -d     Perform relocations and report any missing objects (ELF
              only).

       --function-relocs
       -r     Perform relocations for both data objects and functions,
              and report any missing objects or functions (ELF only).

       --help Usage information.
BUGS
       ldd does not work on a.out shared libraries.

       ldd does not work with some extremely old a.out programs which
       were built before ldd support was added to the compiler releases.
       If you use ldd on one of these programs, the program will attempt
       to run with argc = 0 and the results will be unpredictable.
SEE ALSO
       pldd(1), sprof(1), ld.so(8), ldconfig(8)
COLOPHON
       This page is part of the man-pages (Linux kernel and C library
       user-space interface documentation) project.  Information about
       the project can be found at
       https://www.kernel.org/doc/man-pages/.  If you have a bug report
       for this manual page, see
       https://git.kernel.org/pub/scm/docs/man-pages/man-pages.git/tree/CONTRIBUTING.
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       https://mirrors.edge.kernel.org/pub/linux/docs/man-pages/ on
       2024-06-26.  If you discover any rendering problems in this HTML
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       to-date source for the page, or you have corrections or
       improvements to the information in this COLOPHON (which is not
       part of the original manual page), send a mail to
       man-pages@man7.org

Linux man-pages 6.9.1          2024-05-02                          ldd(1)
```

3.3 lddconfig: Configure Dynamic Linker Run-time Bindings

```
NAME
       ldconfig - configure dynamic linker run-time bindings
SYNOPSIS
       /sbin/ldconfig [-nNvVX] [-C cache] [-f conf] [-r root]
                      directory ...

       /sbin/ldconfig -l [-v] library ...

       /sbin/ldconfig -p
DESCRIPTION
       ldconfig creates the necessary links and cache to the most recent
       shared libraries found in the directories specified on the
       command line, in the file /etc/ld.so.conf, and in the trusted
       directories, /lib and /usr/lib.  On some 64-bit architectures
       such as x86-64, /lib and /usr/lib are the trusted directories for
       32-bit libraries, while /lib64 and /usr/lib64 are used for 64-bit
       libraries.

       The cache is used by the run-time linker, ld.so or ld-linux.so.
       ldconfig checks the header and filenames of the libraries it
       encounters when determining which versions should have their
       links updated.  ldconfig should normally be run by the superuser
       as it may require write permission on some root owned directories
       and files.

       ldconfig will look only at files that are named lib*.so* (for
       regular shared objects) or ld-*.so* (for the dynamic loader
       itself).  Other files will be ignored.  Also, ldconfig expects a
       certain pattern to how the symbolic links are set up, like this
       example, where the middle file (libfoo.so.1 here) is the SONAME
       for the library:

           libfoo.so -> libfoo.so.1 -> libfoo.so.1.12

       Failure to follow this pattern may result in compatibility issues
       after an upgrade.
OPTIONS
       --format=fmt
       -c fmt (Since glibc 2.2) Use cache format fmt, which is one of
              old, new, or compat.  Since glibc 2.32, the default is
              new.  Before that, it was compat.

       -C cache
              Use cache instead of /etc/ld.so.cache.
       -f conf
              Use conf instead of /etc/ld.so.conf.

       --ignore-aux-cache
       -i     (Since glibc 2.7) Ignore auxiliary cache file.

       -l     (Since glibc 2.2) Interpret each operand as a library name
              and configure its links.  Intended for use only by
              experts.

       -n     Process only the directories specified on the command
              line; don't␣process␣the␣trusted␣directories,␣nor␣those
␣␣␣␣␣␣␣␣␣␣␣␣␣␣specified␣in␣/etc/ld.so.conf.␣␣Implies␣-N.

␣␣␣␣␣␣␣-N␣␣␣␣␣Don't rebuild the cache.  Unless -X is also specified,
              links are still updated.

       --print-cache
       -p     Print the lists of directories and candidate libraries
              stored in the current cache.

       -r root
              Change to and use root as the root directory.

       --verbose
       -v     Verbose mode.  Print current version number, the name of
              each directory as it is scanned, and any links that are
              created.  Overrides quiet mode.

       --version
       -V     Print program version.

       -X     Don't␣update␣links.␣␣Unless␣-N␣is␣also␣specified,␣the
␣␣␣␣␣␣␣␣␣␣␣␣␣␣cache␣is␣still␣rebuilt.
FILES
␣␣␣␣␣␣␣/lib/ld.so
␣␣␣␣␣␣␣␣␣␣␣␣␣␣is␣the␣run-time␣linker/loader.
␣␣␣␣␣␣␣/etc/ld.so.conf
␣␣␣␣␣␣␣␣␣␣␣␣␣␣contains␣a␣list␣of␣directories,␣one␣per␣line,␣in␣which␣to
␣␣␣␣␣␣␣␣␣␣␣␣␣␣search␣for␣libraries.
␣␣␣␣␣␣␣/etc/ld.so.cache
␣␣␣␣␣␣␣␣␣␣␣␣␣␣contains␣an␣ordered␣list␣of␣libraries␣found␣in␣the
␣␣␣␣␣␣␣␣␣␣␣␣␣␣directories␣specified␣in␣/etc/ld.so.conf,␣as␣well␣as␣those
␣␣␣␣␣␣␣␣␣␣␣␣␣␣found␣in␣the␣trusted␣directories.
SEE␣ALSO
␣␣␣␣␣␣␣ldd(1),␣ld.so(8)
COLOPHON
␣␣␣␣␣␣␣This␣page␣is␣part␣of␣the␣man-pages␣(Linux␣kernel␣and␣C␣library
␣␣␣␣␣␣␣user-space␣interface␣documentation)␣project.␣␣Information␣about
␣␣␣␣␣␣␣the␣project␣can␣be␣found␣at
␣␣␣␣␣␣␣https://www.kernel.org/doc/man-pages/.␣␣If␣you␣have␣a␣bug␣report
␣␣␣␣␣␣␣for␣this␣manual␣page,␣see
␣␣␣␣␣␣␣https://git.kernel.org/pub/scm/docs/man-pages/man-pages.git/tree/CONTRIBUTING.
␣␣␣␣␣␣␣This␣page␣was␣obtained␣from␣the␣tarball␣man-pages-6.9.1.tar.gz
␣␣␣␣␣␣␣fetched␣from
␣␣␣␣␣␣␣https://mirrors.edge.kernel.org/pub/linux/docs/man-pages/␣on
␣␣␣␣␣␣␣2024-06-26.␣␣If␣you␣discover␣any␣rendering␣problems␣in␣this␣HTML
␣␣␣␣␣␣␣version␣of␣the␣page,␣or␣you␣believe␣there␣is␣a␣better␣or␣more␣up-
␣␣␣␣␣␣␣to-date␣source␣for␣the␣page,␣or␣you␣have␣corrections␣or
␣␣␣␣␣␣␣improvements␣to␣the␣information␣in␣this␣COLOPHON␣(which␣is␣not
␣␣␣␣␣␣␣part␣of␣the␣original␣manual␣page),␣send␣a␣mail␣to
␣␣␣␣␣␣␣man-pages@man7.org

Linux␣man-pages␣6.9.1␣␣␣␣␣␣␣␣␣␣2024-05-02␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣ldconfig(8)
```

3.4 `locate`: List File in Databases

```
NAME
       locate - list files in databases that match a pattern
SYNOPSIS
       locate [-d path | --database=path] [-e | -E | --[non-]existing]
       [-i | --ignore-case] [-0 | --null] [-c | --count] [-w |
       --wholename] [-b | --basename] [-l N | --limit=N] [-S |
       --statistics] [-r | --regex ] [--regextype R] [--max-database-age
       D] [-P | -H | --nofollow] [-L | --follow] [--version] [-A |
       --all] [-p | --print] [--help] pattern...
DESCRIPTION
       This manual page documents the GNU version of locate.  For each
       given pattern, locate searches one or more databases of file
       names and displays the file names that contain the pattern.
       Patterns can contain shell-style metacharacters: ‘*’,␣‘?’, and
       ‘[]’.␣␣The␣metacharacters␣do␣not␣treat␣‘/’ or ‘.’␣␣specially.
␣␣␣␣␣␣␣Therefore,␣a␣pattern␣‘foo*bar’ can match a file name that
       contains ‘foo3/bar’,␣and␣a␣pattern␣‘*duck*’ can match a file name
       that contains ‘lake/.ducky’.␣␣Patterns␣that␣contain
␣␣␣␣␣␣␣metacharacters␣should␣be␣quoted␣to␣protect␣them␣from␣expansion␣by
␣␣␣␣␣␣␣the␣shell.
```

```
␣␣␣␣␣␣␣If␣a␣pattern␣is␣a␣plain␣string␣—␣it␣contains␣no␣metacharacters␣—
␣␣␣␣␣␣␣locate␣displays␣all␣file␣names␣in␣the␣database␣that␣contain␣that
␣␣␣␣␣␣␣string␣anywhere.␣␣If␣a␣pattern␣does␣contain␣metacharacters,
␣␣␣␣␣␣␣locate␣only␣displays␣file␣names␣that␣match␣the␣pattern␣exactly.
␣␣␣␣␣␣␣As␣a␣result,␣patterns␣that␣contain␣metacharacters␣should␣usually
␣␣␣␣␣␣␣begin␣with␣a␣`*', and will most often end with one as well.  The
       exceptions are patterns that are intended to explicitly match the
       beginning or end of a file name.

       The file name databases contain lists of files that were on the
       system when the databases were last updated.  The system
       administrator can choose the file name of the default database,
       the frequency with which the databases are updated, and the
       directories for which they contain entries; see updatedb(1).

       If locate's␣output␣is␣going␣to␣a␣terminal,␣unusual␣characters␣in
␣␣␣␣␣␣␣the␣output␣are␣escaped␣in␣the␣same␣way␣as␣for␣the␣-print␣action
␣␣␣␣␣␣␣of␣the␣find␣command.␣␣If␣the␣output␣is␣not␣going␣to␣a␣terminal,
␣␣␣␣␣␣␣file␣names␣are␣printed␣exactly␣as-is.
OPTIONS
␣␣␣␣␣␣␣-0,␣--null
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Use␣ASCII␣NUL␣as␣a␣separator,␣instead␣of␣newline.

␣␣␣␣␣␣␣-A,␣--all
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Print␣only␣names␣which␣match␣all␣non-option␣arguments,␣not
␣␣␣␣␣␣␣␣␣␣␣␣␣␣those␣matching␣one␣or␣more␣non-option␣arguments.

␣␣␣␣␣␣␣-b,␣--basename
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Results␣are␣considered␣to␣match␣if␣the␣pattern␣specified
␣␣␣␣␣␣␣␣␣␣␣␣␣␣matches␣the␣final␣component␣of␣the␣name␣of␣a␣file␣as
␣␣␣␣␣␣␣␣␣␣␣␣␣␣listed␣in␣the␣database.␣␣This␣final␣component␣is␣usually
␣␣␣␣␣␣␣␣␣␣␣␣␣␣referred␣to␣as␣the␣`base␣name'.

       -c, --count
              Instead of printing the matched filenames, just print the
              total number of matches we found, unless --print (-p) is
              also present.

       -d path, --database=path
              Instead of searching the default file name database,
              search the file name databases in path, which is a colon-
              separated list of database file names.  You can also use
              the environment variable LOCATE_PATH to set the list of
              database files to search.  The option overrides the
              environment variable if both are used.  Empty elements in
              the path are taken to be synonyms for the file name of the
              default database.  A database can be supplied on stdin,
              using `-'␣as␣an␣element␣of␣path.␣If␣more␣than␣one␣element
␣␣␣␣␣␣␣␣␣␣␣␣␣␣of␣path␣is␣`-', later instances are ignored (and a warning
              message is printed).

              The file name database format changed starting with GNU
              find and locate version 4.0 to allow machines with
              different byte orderings to share the databases.  This
              version of locate can automatically recognize and read
              databases produced for older versions of GNU locate or
              Unix versions of locate or find.  Support for the old
              locate database format will be discontinued in a future
              release.

       -e, --existing
              Only print out such names that currently exist (instead of
              such names that existed when the database was created).
              Note that this may slow down the program a lot, if there
              are many matches in the database.  If you are using this
              option within a program, please note that it is possible
              for the file to be deleted after locate has checked that
              it exists, but before you use it.

       -E, --non-existing
              Only print out such names that currently do not exist
              (instead of such names that existed when the database was
              created).  Note that this may slow down the program a lot,
              if there are many matches in the database.

       --help Print a summary of the options to locate and exit.

       -i, --ignore-case
              Ignore case distinctions in both the pattern and the file
              names.

       -l N, --limit=N
              Limit the number of matches to N.  If a limit is set via
              this option, the number of results printed for the -c
              option will never be larger than this number.

       -L, --follow
              If testing for the existence of files (with the -e or -E
              options), consider broken symbolic links to be non-
              existing.   This is the default.

       --max-database-age D
```

```
              Normally, locate will issue a warning message when it
              searches a database which is more than 8 days old.  This
              option changes that value to something other than 8.  The
              effect of specifying a negative value is undefined.

       -m, --mmap
              Accepted but does nothing, for compatibility with BSD
              locate.

       -P, -H, --nofollow
              If testing for the existence of files (with the -e or -E
              options), treat broken symbolic links as if they were
              existing files.  The -H form of this option is provided
              purely for similarity with find; the use of -P is
              recommended over -H.

       -p, --print
              Print search results when they normally would not, because
              of the presence of --statistics (-S) or --count (-c).

       -r, --regex
              The pattern specified on the command line is understood to
              be a regular expression, as opposed to a glob pattern.
              The Regular expressions work in the same was as in emacs
              except for the fact that "." will match a newline.  GNU
              find uses the same regular expressions.  Filenames whose
              full paths match the specified regular expression are
              printed (or, in the case of the -c option, counted).  If
              you wish to anchor your regular expression at the ends of
              the full path name, then as is usual with regular
              expressions, you should use the characters ^ and $ to
              signify this.

       --regextype R
              Use regular expression dialect R.  Supported dialects
              include `findutils-default', `posix-awk', `posix-basic',
              `posix-egrep', `posix-extended', `posix-minimal-basic',
              `awk', `ed', `egrep', `emacs', `gnu-awk', `grep' and
              `sed'.  See the Texinfo documentation for a detailed
              explanation of these dialects.

       -s, --stdio
              Accepted but does nothing, for compatibility with BSD
              locate.

       -S, --statistics
              Print various statistics about each locate database and
              then exit without performing a search, unless non-option
              arguments are given.  For compatibility with BSD, -S is
              accepted as a synonym for --statistics.  However, the
              output of locate -S is different for the GNU and BSD
              implementations of locate.

       --version
              Print the version number of locate and exit.

       -w, --wholename
              Match against the whole name of the file as listed in the
              database.  This is the default.
ENVIRONMENT
       LOCATE_PATH
              Colon-separated list of databases to search.  If the value
              has a leading or trailing colon, or has two colons in a
              row, you may get results that vary between different
              versions of locate.
HISTORY
       The locate program started life as the BSD fast find program,
       contributed to BSD by James A. Woods.  This was described by his
       paper Finding Files Fast which was published in Usenix ;login:,
       Vol 8, No 1, February/March, 1983, pp. 8-10.   When the find
       program began to assume a default -print action if no action was
       specified, this changed the interpretation of find pattern.  The
       BSD developers therefore moved the fast find functionality into
       locate.  The GNU implementation of locate appears to be derived
       from the same code.

       Significant changes to locate in reverse order:
       4.3.7     Byte-order independent support for old database format
       4.3.3     locate -i supports multi-byte characters correctly
                 Introduced --max_db_age
       4.3.2     Support for the slocate database format
       4.2.22    Introduced the --all option
       4.2.15    Introduced the --regex option
       4.2.14    Introduced options -L, -P, -H
       4.2.12    Empty items in LOCATE_PATH now indicate the default database
       4.2.11    Introduced the --statistics option
       4.2.4     Introduced --count and --limit
       4.2.0     Glob characters cause matching against the whole file name
       4.0       Introduced the LOCATE02 database format
       3.7       Locate can search multiple databases
BUGS
       The locate database correctly handles filenames containing
```

```
␣␣␣␣␣␣␣newlines,␣but␣only␣if␣the␣system's sort command has a working −z
       option.  If you suspect that locate may need to return filenames
       containing newlines, consider using its −−null option.
REPORTING BUGS
       GNU findutils online help:
       <https://www.gnu.org/software/findutils/#get−help>
       Report any translation bugs to
       <https://translationproject.org/team/>

       Report any other issue via the form at the GNU Savannah bug
       tracker:
              <https://savannah.gnu.org/bugs/?group=findutils>
       General topics about the GNU findutils package are discussed at
       the bug−findutils mailing list:
              <https://lists.gnu.org/mailman/listinfo/bug−findutils>
COPYRIGHT
       Copyright (C) 1994−2024 Free Software Foundation, Inc.  License
       GPLv3+: GNU GPL version 3 or later
       <https://gnu.org/licenses/gpl.html>.
       This is free software: you are free to change and redistribute
       it.  There is NO WARRANTY, to the extent permitted by law.
SEE ALSO
       find(1), updatedb(1), xargs(1), glob(3), locatedb(5)

       Full documentation
       <https://www.gnu.org/software/findutils/locate>
       or available locally via: info locate
COLOPHON
       This page is part of the findutils (find utilities) project.
       Information about the project can be found at
       http://www.gnu.org/software/findutils/.  If you have a bug
       report for this manual page, see
       https://savannah.gnu.org/bugs/?group=findutils.  This page was
       obtained from the project's␣upstream␣Git␣repository
␣␣␣␣␣␣␣git://git.savannah.gnu.org/findutils.git␣on␣2024−06−14.␣␣(At
␣␣␣␣␣␣␣that␣time,␣the␣date␣of␣the␣most␣recent␣commit␣that␣was␣found␣in
␣␣␣␣␣␣␣the␣repository␣was␣2024−06−03.)␣␣If␣you␣discover␣any␣rendering
␣␣␣␣␣␣␣problems␣in␣this␣HTML␣version␣of␣the␣page,␣or␣you␣believe␣there
␣␣␣␣␣␣␣is␣a␣better␣or␣more␣up−to−date␣source␣for␣the␣page,␣or␣you␣have
␣␣␣␣␣␣␣corrections␣or␣improvements␣to␣the␣information␣in␣this␣COLOPHON
␣␣␣␣␣␣␣(which␣is␣not␣part␣of␣the␣original␣manual␣page),␣send␣a␣mail␣to
␣␣␣␣␣␣␣man−pages@man7.org

␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣LOCATE(1)
```

3.5 `lsof`: Show Open Files

```
NAME
       lsof − list open files
SYNOPSIS
       lsof [ −?abChlnNOPRtUvVX ] [ −A A ] [ −c c ] [ +c c ] [ +|−d d ]
       [ +|−D D ] [ +|−e s ] [ +|−E ] [ +|−f [cfgGn] ] [ −F [f] ] [ −g
       [s] ] [ −i [i] ] [ −k k ] [ −K k ] [ +|−L [l] ] [ +|−m m ] [ +|−M
       ] [ −o [o] ] [ −p s ] [ +|−r [t[m<fmt>]] ] [ −s [p:s] ] [ −S [t]
       ] [ −T [t] ] [ −u s ] [ +|−w ] [ −x [fl] ] [ −z [z] ] [ −Z [Z] ]
       [ −− ] [names]
DESCRIPTION
       Lsof revision 4.91 lists on its standard output file information
       about files opened by processes for the following UNIX dialects:

            Apple Darwin 9 and Mac OS X 10.[567]
            FreeBSD 8.[234], 9.0 and 1[012].0 for AMD64−based systems
            Linux 2.1.72 and above for x86−based systems
            Solaris 9, 10 and 11

       (See the DISTRIBUTION section of this manual page for information
       on how to obtain the latest lsof revision.)

       An open file may be a regular file, a directory, a block special
       file, a character special file, an executing text reference, a
       library, a stream or a network file (Internet socket, NFS file or
       UNIX domain socket.)  A specific file or all the files in a file
       system may be selected by path.

       Instead of a formatted display, lsof will produce output that can
       be parsed by other programs.  See the −F, option description, and
       the OUTPUT FOR OTHER PROGRAMS section for more information.

       In addition to producing a single output list, lsof will run in
       repeat mode.  In repeat mode it will produce output, delay, then
       repeat the output operation until stopped with an interrupt or
       quit signal.  See the +|−r [t[m<fmt>]] option description for
       more information.
OPTIONS
       In the absence of any options, lsof lists all open files
       belonging to all active processes.

       If any list request option is specified, other list requests must
```

be specifically requested − e.g., **if** −U is specified **for** the listing of UNIX socket files, NFS files won't be listed unless −N is also specified; or if a user list is specified with the −u option, UNIX domain socket files, belonging to users not in the list, won't be listed unless the −U option is also specified.

Normally list options that are specifically stated are ORed − i.e., specifying the −i option without an address and the −ufoo option produces a listing of all network files OR files belonging to processes owned by user ''foo''. The exceptions are:

1) the '^' (negated) login name or user ID (UID), specified with the −u option;

2) the '^' (negated) process ID (PID), specified with the −p option;

3) the '^' (negated) process group ID (PGID), specified with the −g option;

4) the '^' (negated) **command**, specified with the −c option;

5) the ('^') negated TCP or UDP protocol state names, specified with the −s [p:s] option.

Since they represent exclusions, they are applied without ORing or ANDing and take effect before any other selection criteria are applied.

The −a option may be used to AND the selections. For example, specifying −a, −U, and −ufoo produces a listing of only UNIX socket files that belong to processes owned by user ''foo''.

Caution: the −a option causes all list selection options to be ANDed; it can't be used to cause ANDing of selected pairs of selection options by placing it between them, even though its placement there is acceptable. Wherever −a is placed, it causes the ANDing of all selection options.

Items of the same selection **set** − **command** names, file descriptors, network addresses, process identifiers, user identifiers, zone names, security contexts − are joined **in** a single ORed **set** and applied before the result participates **in** ANDing. Thus, **for** example, specifying −i@aaa.bbb, −i@ccc.ddd, −a, and −ufff,ggg will **select** the listing of files that belong to either **login** ''fff'' OR ''ggg'' AND have network connections to either host aaa.bbb OR ccc.ddd.

Options may be grouped together following a single prefix −− e.g., the option **set** ''−a −b −C'' may be stated as −abC. However, since values are optional following +|−f, −F, −g, −i, +|−L, −o, +|−r, −s, −S, −T, −x and −z. when you have no values **for** them be careful that the following character isn't ambiguous. For example, −Fn might represent the −F and −n options, or it might represent the n field identifier character following the −F option. When ambiguity is possible, start a new option with a '−' character − e.g., ''−F −n''. If the next option is a file name, follow the possibly ambiguous option with ''−−'' − e.g., ''−F −− name''.

Either the '+' or the '−' prefix may be applied to a group of options. Options that don't take on separate meanings for each prefix − e.g., −i − may be grouped under either prefix. Thus, for example, ''+M −i'' may be stated as ''+Mi'' and the group means the same as the separate options. Be careful of prefix grouping when one or more options in the group does take on separate meanings under different prefixes − e.g., +|−M; ''−iM'' is not the same request as ''−i +M''. When in doubt, use separate options with appropriate prefixes.

−? −h These two equivalent options select a usage (help) output list. Lsof displays a shortened form of this output when it detects an error in the options supplied to it, after it has displayed messages explaining each error. (Escape the '?' character as your shell requires.)

−a causes list selection options to be ANDed, as described above.

−A A is available on systems configured **for** AFS whose AFS kernel code is implemented via dynamic modules. It allows the lsof user to specify A as an alternate name list file where the kernel addresses of the dynamic modules might be found. See the lsof FAQ (The FAQ section gives its location.) **for** more information about dynamic modules, their symbols, and how they affect lsof.

−b causes lsof to avoid kernel functions that might block − lstat(2), readlink(2), and stat(2).

See the BLOCKS AND TIMEOUTS and AVOIDING KERNEL BLOCKS sections **for** information on using this option.

−c c selects the listing of files **for** processes executing the **command** that begins with the characters of c. Multiple commands may be specified, using multiple −c options. They are joined **in** a single ORed **set** before participating **in** AND option selection.

If c begins with a '^', then the following characters specify a command name whose processes are to be ignored (excluded.)

If c begins and ends with a slash ('/'), the characters between the slashes are interpreted as a regular expression. Shell meta−characters in the regular expression must be quoted to prevent their interpretation by the shell. The closing slash may be followed by these modifiers:

b the regular expression is a basic one.
i ignore the case of letters.
x the regular expression is an extended one (default).

See the lsof FAQ (The FAQ section gives its location.) for more information on basic and extended regular expressions.

The simple command specification is tested first. If that test fails, the command regular expression is applied. If the simple command test succeeds, the command regular expression test isn't made. This may result **in** ''no **command** found **for** regex:'' messages when lsof's −V option is specified.

+c w defines the maximum number of initial characters of the name, supplied by the UNIX dialect, of the UNIX command associated with a process to be printed in the COMMAND column. (The lsof default is nine.)

Note that many UNIX dialects do not supply all command name characters to lsof in the files and structures from which lsof obtains command name. Often dialects limit the number of characters supplied in those sources. For example, Linux 2.4.27 and Solaris 9 both limit command name length to 16 characters.

If w is zero ('0'), all command characters supplied to lsof by the UNIX dialect will be printed.

If w is less than the length of the column title, ''COMMAND'', it will be raised to that length.

−C disables the reporting of any path name components from the kernel's name cache. See the KERNEL NAME CACHE section **for** more information.

+d s causes lsof to search **for** all open instances of directory s and the files and directories it contains at its top level. +d does NOT descend the directory tree, rooted at s. The +D D option may be used to request a full−descent directory tree search, rooted at directory D.

Processing of the +d option does not follow symbolic links within s unless the −x or −x l option is also specified. Nor does it search **for** open files on file system mount points on subdirectories of s unless the −x or −x f option is also specified.

Note: the authority of the user of this option limits it to searching **for** files that the user has permission to examine with the system stat(2) **function**.

−d s specifies a list of file descriptors (FDs) to exclude from or include **in** the output listing. The file descriptors are specified **in** the comma−separated **set** s − e.g., ''cwd,1,3'', ''^6,^2''. (There should be no spaces **in** the **set**.)

The list is an exclusion list **if** all entries of the **set** begin with '^'. It is an inclusion list if no entry begins with '^'. Mixed lists are not permitted.

A file descriptor number range may be **in** the **set** as long as neither member is empty, both members are numbers, and the ending member is larger than the starting one − e.g., ''0−7'' or ''3−10''. Ranges may be specified **for** exclusion **if** they have the '^' prefix − e.g., ''^0−7'' excludes all file descriptors 0 through 7.

Multiple file descriptor numbers are joined in a single ORed set before participating in AND option selection.

```
              When there are exclusion and inclusion members in the set,
              lsof reports them as errors and exits with a non-zero
              return code.

              See the description of File Descriptor (FD) output values
              in the OUTPUT section for more information on file
              descriptor names.

       +D D   causes lsof to search for all open instances of directory
              D and all the files and directories it contains to its
              complete depth.

              Processing of the +D option does not follow symbolic links
              within D unless the -x or -x  l option is also specified.
              Nor does it search for open files on file system mount
              points on subdirectories of D unless the -x or -x  f
              option is also specified.

              Note: the authority of the user of this option limits it
              to searching for files that the user has permission to
              examine with the system stat(2) function.

              Further note: lsof may process this option slowly and
              require a large amount of dynamic memory to do it.  This
              is because it must descend the entire directory tree,
              rooted at D, calling stat(2) for each file and directory,
              building a list of all the files it finds, and searching
              that list for a match with every open file.  When
              directory D is large, these steps can take a long time, so
              use this option prudently.

       -D D   directs lsof's use of the device cache file.  The use of
              this option is sometimes restricted.  See the DEVICE CACHE
              FILE section and the sections that follow it for more
              information on this option.

              -D must be followed by a function letter; the function
              letter may optionally be followed by a path name.  Lsof
              recognizes these function letters:

                   ? - report device cache file paths
                   b - build the device cache file
                   i - ignore the device cache file
                   r - read the device cache file
                   u - read and update the device cache file

              The b, r, and u functions, accompanied by a path name, are
              sometimes restricted.  When these functions are
              restricted, they will not appear in the description of the
              -D option that accompanies -h or -? option output.  See
              the DEVICE CACHE FILE section and the sections that follow
              it for more information on these functions and when
              they're restricted.

              The ?  function reports the read-only and write paths that
              lsof can use for the device cache file, the names of any
              environment variables whose values lsof will examine when
              forming the device cache file path, and the format for the
              personal device cache file path.  (Escape the '?'
              character as your shell requires.)

              When available, the b, r, and u functions may be followed
              by the device cache file's path.  The standard default is
              .lsof_hostname in the home directory of the real user ID
              that executes lsof, but this could have been changed when
              lsof was configured and compiled.  (The output of the -h
              and -?  options show the current default prefix - e.g.,
              ``.lsof''.)  The suffix, hostname, is the first component
              of the host's name returned by gethostname(2).

              When available, the b function directs lsof to build a new
              device cache file at the default or specified path.

              The i function directs lsof to ignore the default device
              cache file and obtain its information about devices via
              direct calls to the kernel.

              The r function directs lsof to read the device cache at
              the default or specified path, but prevents it from
              creating a new device cache file when none exists or the
              existing one is improperly structured.  The r function,
              when specified without a path name, prevents lsof from
              updating an incorrect or outdated device cache file, or
              creating a new one in its place.  The r function is always
              available when it is specified without a path name
              argument; it may be restricted by the permissions of the
              lsof process.

              When available, the u function directs lsof to read the
              device cache file at the default or specified path, if
              possible, and to rebuild it, if necessary.  This is the
              default device cache file function when no -D option has
```

been specified.

+|−e s exempts the file system whose path name is s from being subjected to kernel **function** calls that might block. The +e option exempts stat(2), lstat(2) and most readlink(2) kernel **function** calls. The −e option exempts only stat(2) and lstat(2) kernel **function** calls. Multiple file systems may be specified with separate +|−e specifications and each may have readlink(2) calls exempted or not.

This option is currently implemented only **for** Linux.

CAUTION: this option can easily be mis−applied to other than the file system of interest, because it uses path name rather than the more reliable device and inode numbers. (Device and inode numbers are acquired via the potentially blocking stat(2) kernel call and are thus not available, but see the +|−m m option as a possible alternative way to supply device numbers.) Use this option with great care and fully specify the path name of the file system to be exempted.

When open files on exempted file systems are reported, it may not be possible to obtain all their information. Therefore, some information columns will be blank, the characters ''UNKN'' preface the values **in** the TYPE column, and the applicable exemption option is added **in** parentheses to the end of the NAME column. (Some device number information might be made available via the +|−m m option.)

+|−E +E specifies that Linux pipe, Linux UNIX socket and Linux pseudoterminal files should be displayed with endpoint information and the files of the endpoints should also be displayed. Note: UNIX socket file endpoint information is only available when the compile flags line of −v output contains HASUXSOCKEPT, and psudoterminal endpoint information is only available when the compile flags line contains HASPTYEPT.

Pipe endpoint information is displayed **in** the NAME column **in** the form ''PID,cmd,FDmode'', where PID is the endpoint process ID; cmd is the endpoint process **command**; FD is the endpoint file's␣descriptor;␣and␣mode␣is␣the␣endpoint ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣file's access mode.

Pseudoterminal endpoint information is displayed **in** the NAME column as ''−>/dev/ptsmin PID,cmd,FDmode'' or ''PID,cmd,FDmode''. The first form is **for** a master device; the second, **for** a slave device. min is a slave device's␣minor␣device␣number;␣and␣PID,␣cmd,␣FD␣and␣mode ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣are␣the␣same␣as␣with␣pipe␣endpoint␣information.␣␣Note: ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣psudoterminal␣endpoint␣information␣is␣only␣available␣when ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣the␣compile␣flags␣line␣of␣−V␣output␣contains␣HASPTYEPT.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣UNIX␣socket␣file␣endpoint␣information␣is␣displayed␣in␣the ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣NAME␣column␣in␣the␣form ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣''type=TYPE␣−>INO=INODE␣PID,cmd,FDmode'',␣where␣TYPE␣is ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣the␣socket␣type;␣INODE␣is␣the␣i−node␣number␣of␣the ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣connected␣socket;␣and␣PID,␣cmd,␣FD␣and␣mode␣are␣the␣same ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣as␣with␣pipe␣endpoint␣information.␣␣Note:␣UNIX␣socket␣file ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣endpoint␣information␣is␣available␣only␣when␣the␣compile ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣flags␣line␣of␣−v␣output␣contains␣HASUXSOCKEPT.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣Multiple␣occurrences␣of␣this␣information␣can␣appear␣in␣a ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣file's NAME column.

−E specfies that Linux pipe and Linux UNIX socket files should be displayed with endpoint information, but not the files of the endpoints.

+|−f [cfgGn]
f by itself clarifies how path name arguments are to be interpreted. When followed by c, f, g, G, or n **in** any combination it specifies that the listing of kernel file structure information is to be enabled ('+')␣or␣inhibited ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣('−').

Normally a path name argument is taken to be a file system name **if** it matches a mounted−on directory name reported by mount(8), or **if** it represents a block device, named **in** the mount output and associated with a mounted directory name. When +f is specified, all path name arguments will be taken to be file system names, and lsof will complain **if** any are not. This can be useful, **for** example, when the file system name (mounted−on device) isn't␣a␣block␣device. ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣This␣happens␣for␣some␣CD−ROM␣file␣systems.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣When␣−f␣is␣specified␣by␣itself,␣all␣path␣name␣arguments ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣will␣be␣taken␣to␣be␣simple␣files.␣␣Thus,␣for␣example,␣the ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣''−f␣−−␣/''␣arguments␣direct␣lsof␣to␣search␣for␣open␣files ␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣with␣a␣'/' path name, not all open files **in** the '/'␣(root) file system.

Be careful to make sure +f and −f are properly terminated and aren't followed by a character (e.g., of the file or file system name) that might be taken as a parameter. For example, use ''−−'' after +f and −f as in these examples.

```
     $ lsof +f −− /file/system/name
     $ lsof −f −− /file/name
```

The listing of information from kernel file structures, requested with the +f [cfgGn] option form, is normally inhibited, and is not available in whole or part for some dialects − e.g., /proc−based Linux kernels below 2.6.22. When the prefix to f is a plus sign ('+'), these characters request file structure information:

```
     c    file structure use count (not Linux)
     f    file structure address (not Linux)
     g    file flag abbreviations (Linux 2.6.22 and up)
     G    file flags in hexadecimal (Linux 2.6.22 and up)
     n    file structure node address (not Linux)
```

When the prefix is minus ('−') the same characters disable the listing of the indicated values.

File structure addresses, use counts, flags, and node addresses may be used to detect more readily identical files inherited by child processes and identical files in use by different processes. Lsof column output can be sorted by output columns holding the values and listed to identify identical file use, or lsof field output can be parsed by an AWK or Perl post−filter script, or by a C program.

−F f   specifies a character list, f, that selects the fields to be output for processing by another program, and the character that terminates each output field. Each field to be output is specified with a single character in f. The field terminator defaults to NL, but may be changed to NUL (000). See the OUTPUT FOR OTHER PROGRAMS section for a description of the field identification characters and the field output process.

When the field selection character list is empty, all standard fields are selected (except the raw device field, security context and zone field for compatibility reasons) and the NL field terminator is used.

When the field selection character list contains only a zero ('0'), all fields are selected (except the raw device field for compatibility reasons) and the NUL terminator character is used.

Other combinations of fields and their associated field terminator character must be set with explicit entries in f, as described in the OUTPUT FOR OTHER PROGRAMS section.

When a field selection character identifies an item lsof does not normally list − e.g., PPID, selected with −R − specification of the field character − e.g., ''−FR'' − also selects the listing of the item.

When the field selection character list contains the single character '?', lsof will display a help list of the field identification characters. (Escape the '?' character as your shell requires.)

−g [s] excludes or selects the listing of files for the processes whose optional process group IDentification (PGID) numbers are in the comma−separated set s − e.g., ''123'' or ''123,^456''. (There should be no spaces in the set.)

PGID numbers that begin with '^' (negation) represent exclusions.

Multiple PGID numbers are joined in a single ORed set before participating in AND option selection. However, PGID exclusions are applied without ORing or ANDing and take effect before other selection criteria are applied.

The −g option also enables the output display of PGID numbers. When specified without a PGID set that's all it does.

−i [i] selects the listing of files any of whose Internet address matches the address specified in i. If no address is specified, this option selects the listing of all Internet and x.25 (HP−UX) network files.

If −i4 or −i6 is specified with no following address, only files of the indicated IP version, IPv4 or IPv6, are

```
␣␣␣␣␣␣␣␣␣␣␣␣␣␣displayed.␣␣(An␣IPv6␣specification␣may␣be␣used␣only␣if␣the
␣␣␣␣␣␣␣␣␣␣␣␣␣␣dialects␣supports␣IPv6,␣as␣indicated␣by␣‘‘[46]’’␣and
␣␣␣␣␣␣␣␣␣␣␣␣␣␣‘‘IPv[46]’’␣in␣lsof's -h or -?  output.)  Sequentially
              specifying -i4, followed by -i6 is the same as specifying
              -i, and vice-versa.  Specifying -i4, or -i6 after -i is
              the same as specifying -i4 or -i6 by itself.

              Multiple addresses (up to a limit of 100) may be specified
              with multiple -i options.  (A port number or service name
              range is counted as one address.)  They are joined in a
              single ORed set before participating in AND option
              selection.

              An Internet address is specified in the form (Items in
              square brackets are optional.):

              [46][protocol][@hostname|hostaddr][:service|port]

              where:
                   46 specifies the IP version, IPv4 or IPv6
                        that applies to the following address.
                        '6' may be be specified only if the UNIX
                        dialect supports IPv6.  If neither '4' nor
                        '6' is specified, the following address
                        applies to all IP versions.
                   protocol is a protocol name - TCP, UDP
                   hostname is an Internet host name.  Unless a
                        specific IP version is specified, open
                        network files associated with host names
                        of all versions will be selected.
                   hostaddr is a numeric Internet IPv4 address in
                        dot form; or an IPv6 numeric address in
                        colon form, enclosed in brackets, if the
                        UNIX dialect supports IPv6.  When an IP
                        version is selected, only its numeric
                        addresses may be specified.
                   service is an /etc/services name - e.g., smtp -
                        or a list of them.
                   port is a port number, or a list of them.

              IPv6 options may be used only if the UNIX dialect supports
              IPv6.  To see if the dialect supports IPv6, run lsof and
              specify the -h or -? (help) option.  If the displayed
              description of the -i option contains ‘‘[46]’’ and
              ‘‘IPv[46]’’, IPv6 is supported.

              IPv4 host names and addresses may not be specified if
              network file selection is limited to IPv6 with -i 6.  IPv6
              host names and addresses may not be specified if network
              file selection is limited to IPv4 with -i 4.  When an open
              IPv4 network file's␣address␣is␣mapped␣in␣an␣IPv6␣address,
␣␣␣␣␣␣␣␣␣␣␣␣␣␣the␣open␣file's type will be IPv6, not IPv4, and its
              display will be selected by '6', not '4'.

              At least one address component - 4, 6, protocol, hostname,
              hostaddr, or service - must be supplied.  The ‘@’
␣␣␣␣␣␣␣␣␣␣␣␣␣␣character,␣leading␣the␣host␣specification,␣is␣always
␣␣␣␣␣␣␣␣␣␣␣␣␣␣required;␣as␣is␣the␣‘:', leading the port specification.
              Specify either hostname or hostaddr.  Specify either
              service name list or port number list.  If a service name
              list is specified, the protocol may also need to be
              specified if the TCP, UDP and UDPLITE port numbers for the
              service name are different.  Use any case - lower or upper
              - for protocol.

              Service names and port numbers may be combined in a list
              whose entries are separated by commas and whose numeric
              range entries are separated by minus signs.  There may be
              no embedded spaces, and all service names must belong to
              the specified protocol.  Since service names may contain
              embedded minus signs, the starting entry of a range can't
␣␣␣␣␣␣␣␣␣␣␣␣␣␣be␣a␣service␣name;␣it␣can␣be␣a␣port␣number,␣however.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣Here␣are␣some␣sample␣addresses:

␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣-i6␣-␣IPv6␣only
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣TCP:25␣-␣TCP␣and␣port␣25
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣@1.2.3.4␣-␣Internet␣IPv4␣host␣address␣1.2.3.4
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣@[3ffe:1ebc::1]:1234␣-␣Internet␣IPv6␣host␣address
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣3ffe:1ebc::1,␣port␣1234
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣UDP:who␣-␣UDP␣who␣service␣port
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣TCP@lsof.itap:513␣-␣TCP,␣port␣513␣and␣host␣name␣lsof.itap
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣tcp@foo:1-10,smtp,99␣-␣TCP,␣ports␣1␣through␣10,
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣service␣name␣smtp,␣port␣99,␣host␣name␣foo
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣tcp@bar:1-smtp␣-␣TCP,␣ports␣1␣through␣smtp,␣host␣bar
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣:time␣-␣either␣TCP,␣UDP␣or␣UDPLITE␣time␣service␣port

␣␣␣␣␣␣␣-K␣k␣␣␣selects␣the␣listing␣of␣tasks␣(threads)␣of␣processes,␣on
␣␣␣␣␣␣␣␣␣␣␣␣␣␣dialects␣where␣task␣(thread)␣reporting␣is␣supported.␣␣(If
␣␣␣␣␣␣␣␣␣␣␣␣␣␣help␣output␣-␣i.e.,␣the␣output␣of␣the␣-h␣or␣-?␣␣options␣-
␣␣␣␣␣␣␣␣␣␣␣␣␣␣shows␣this␣option,␣then␣task␣(thread)␣reporting␣is
␣␣␣␣␣␣␣␣␣␣␣␣␣␣supported␣by␣the␣dialect.)
```

```
              If -K is followed by a value, k, it must be ``i''.  That
              causes lsof to ignore tasks, particularly in the default,
              list-everything case when no other options are specified.

              When -K and -a are both specified on Linux, and the tasks
              of a main process are selected by other options, the main
              process will also be listed as though it were a task, but
              without a task ID.  (See the description of the TID column
              in the OUTPUT section.)

              Where the FreeBSD version supports threads, all threads
              will be listed with their IDs.

              In general threads and tasks inherit the files of the
              caller, but may close some and open others, so lsof always
              reports all the open files of threads and tasks.

       -k k   specifies a kernel name list file, k, in place of /vmunix,
              /mach, etc.  -k is not available under AIX on the IBM
              RISC/System 6000.

       -l     inhibits the conversion of user ID numbers to login names.
              It is also useful when login name lookup is working
              improperly or slowly.

       +|-L [l]
              enables ('+') or disables ('-') the listing of file link
              counts, where they are available - e.g., they aren't
              available for sockets, or most FIFOs and pipes.

              When +L is specified without a following number, all link
              counts will be listed.  When -L is specified (the
              default), no link counts will be listed.

              When +L is followed by a number, only files having a link
              count less than that number will be listed.  (No number
              may follow -L.)  A specification of the form ``+L1'' will
              select open files that have been unlinked.  A
              specification of the form ``+aL1 <file_system>'' will
              select unlinked open files on the specified file system.

              For other link count comparisons, use field output (-F)
              and a post-processing script or program.

       +|-m m specifies an alternate kernel memory file or activates
              mount table supplement processing.

              The option form -m m specifies a kernel memory file, m, in
              place of /dev/kmem or /dev/mem - e.g., a crash dump file.

              The option form +m requests that a mount supplement file
              be written to the standard output file.  All other options
              are silently ignored.

              There will be a line in the mount supplement file for each
              mounted file system, containing the mounted file system
              directory, followed by a single space, followed by the
              device number in hexadecimal "0x" format - e.g.,

                   / 0x801

              Lsof can use the mount supplement file to get device
              numbers for file systems when it can't get them via
              stat(2) or lstat(2).

              The option form +m m identifies m as a mount supplement
              file.

              Note: the +m and +m m options are not available for all
              supported dialects.  Check the output of lsof's -h or -?
              options to see if the +m and +m m options are available.

       +|-M   Enables (+) or disables (-) the reporting of portmapper
              registrations for local TCP, UDP and UDPLITE ports, where
              port mapping is supported.  (See the last paragraph of
              this option description for information about where
              portmapper registration reporting is supported.)

              The default reporting mode is set by the lsof builder with
              the HASPMAPENABLED #define in the dialect's machine.h
              header file; lsof is distributed with the HASPMAPENABLED
              #define deactivated, so portmapper reporting is disabled
              by default and must be requested with +M.  Specifying
              lsof's -h or -?  option will report the default mode.
              Disabling portmapper registration when it is already
              disabled or enabling it when already enabled is
              acceptable.  When portmapper registration reporting is
              enabled, lsof displays the portmapper registration (if
              any) for local TCP, UDP or UDPLITE ports in square
              brackets immediately following the port numbers or service
              names - e.g., ``:1234[name]'' or ``:name[100083]''.  The
              registration information may be a name or number,
              depending on what the registering program supplied to the
              portmapper when it registered the port.

              When portmapper registration reporting is enabled, lsof
              may run a little more slowly or even become blocked when
              access to the portmapper becomes congested or stopped.
              Reverse the reporting mode to determine if portmapper
              registration reporting is slowing or blocking lsof.

              For purposes of portmapper registration reporting lsof
              considers a TCP, UDP or UDPLITE port local if: it is found
              in the local part of its containing kernel structure; or
              if it is located in the foreign part of its containing
              kernel structure and the local and foreign Internet
              addresses are the same; or if it is located in the foreign
              part of its containing kernel structure and the foreign
              Internet address is INADDR_LOOPBACK (127.0.0.1).  This
              rule may make lsof ignore some foreign ports on machines
              with multiple interfaces when the foreign Internet address
              is on a different interface from the local one.

              See the lsof FAQ (The FAQ section gives its location.)
              for further discussion of portmapper registration
              reporting issues.

              Portmapper registration reporting is supported only on
              dialects that have RPC header files.  (Some Linux
              distributions with GlibC 2.14 do not have them.)  When
              portmapper registration reporting is supported, the -h or
              -?  help output will show the +|-M option.

       -n     inhibits the conversion of network numbers to host names
              for network files.  Inhibiting conversion may make lsof
              run faster.  It is also useful when host name lookup is
              not working properly.

       -N     selects the listing of NFS files.

       -o     directs lsof to display file offset at all times.  It
              causes the SIZE/OFF output column title to be changed to
              OFFSET.  Note: on some UNIX dialects lsof can't obtain
              accurate or consistent file offset information from its
              kernel data sources, sometimes just for particular kinds
              of files (e.g., socket files.)  Consult the lsof FAQ (The
              FAQ section gives its location.)  for more information.

              The -o and -s options are mutually exclusive; they can't
              both be specified.  When neither is specified, lsof
              displays whatever value - size or offset - is appropriate
              and available for the type of the file.

       -o o   defines the number of decimal digits (o) to be printed
              after the ``0t'' for a file offset before the form is
              switched to ``0x...''.  An o value of zero (unlimited)
              directs lsof to use the ``0t'' form for all offset output.

              This option does NOT direct lsof to display offset at all
              times; specify -o (without a trailing number) to do that.
              -o o only specifies the number of digits after ``0t'' in
              either mixed size and offset or offset-only output.  Thus,
              for example, to direct lsof to display offset at all times
              with a decimal digit count of 10, use:

                   -o -o 10
              or
                   -oo10

              The default number of digits allowed after ``0t'' is
              normally 8, but may have been changed by the lsof builder.
              Consult the description of the -o o option in the output
              of the -h or -?  option to determine the default that is
              in effect.

       -O     directs lsof to bypass the strategy it uses to avoid being
              blocked by some kernel operations - i.e., doing them in
              forked child processes.  See the BLOCKS AND TIMEOUTS and
              AVOIDING KERNEL BLOCKS sections for more information on
              kernel operations that may block lsof.

              While use of this option will reduce lsof startup
              overhead, it may also cause lsof to hang when the kernel
              doesn't respond to a function.  Use this option
              cautiously.

       -p s   excludes or selects the listing of files for the processes
              whose optional process IDentification (PID) numbers are in
              the comma-separated set s - e.g., ``123'' or ``123,^456''.
              (There should be no spaces in the set.)

              PID numbers that begin with `^' (negation) represent
              exclusions.
```

```
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Multiple␣process␣ID␣numbers␣are␣joined␣in␣a␣single␣ORed
␣␣␣␣␣␣␣␣␣␣␣␣␣␣set␣before␣participating␣in␣AND␣option␣selection.
␣␣␣␣␣␣␣␣␣␣␣␣␣␣However,␣PID␣exclusions␣are␣applied␣without␣ORing␣or
␣␣␣␣␣␣␣␣␣␣␣␣␣␣ANDing␣and␣take␣effect␣before␣other␣selection␣criteria␣are
␣␣␣␣␣␣␣␣␣␣␣␣␣␣applied.

␣␣␣␣␣␣␣-P␣␣␣␣␣inhibits␣the␣conversion␣of␣port␣numbers␣to␣port␣names␣for
␣␣␣␣␣␣␣␣␣␣␣␣␣␣network␣files.␣␣Inhibiting␣the␣conversion␣may␣make␣lsof
␣␣␣␣␣␣␣␣␣␣␣␣␣␣run␣a␣little␣faster.␣␣It␣is␣also␣useful␣when␣port␣name
␣␣␣␣␣␣␣␣␣␣␣␣␣␣lookup␣is␣not␣working␣properly.

␣␣␣␣␣␣␣+|-r␣[t[m<fmt>]]
␣␣␣␣␣␣␣␣␣␣␣␣␣␣puts␣lsof␣in␣repeat␣mode.␣␣There␣lsof␣lists␣open␣files␣as
␣␣␣␣␣␣␣␣␣␣␣␣␣␣selected␣by␣other␣options,␣delays␣t␣seconds␣(default
␣␣␣␣␣␣␣␣␣␣␣␣␣␣fifteen),␣then␣repeats␣the␣listing,␣delaying␣and␣listing
␣␣␣␣␣␣␣␣␣␣␣␣␣␣repetitively␣until␣stopped␣by␣a␣condition␣defined␣by␣the
␣␣␣␣␣␣␣␣␣␣␣␣␣␣prefix␣to␣the␣option.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣If␣the␣prefix␣is␣a␣`-', repeat mode is endless.  Lsof must
              be terminated with an interrupt or quit signal.

              If the prefix is `+',␣repeat␣mode␣will␣end␣the␣first␣cycle
␣␣␣␣␣␣␣␣␣␣␣␣␣␣no␣open␣files␣are␣listed␣-␣and␣of␣course␣when␣lsof␣is
␣␣␣␣␣␣␣␣␣␣␣␣␣␣stopped␣with␣an␣interrupt␣or␣quit␣signal.␣␣When␣repeat
␣␣␣␣␣␣␣␣␣␣␣␣␣␣mode␣ends␣because␣no␣files␣are␣listed,␣the␣process␣exit
␣␣␣␣␣␣␣␣␣␣␣␣␣␣code␣will␣be␣zero␣if␣any␣open␣files␣were␣ever␣listed;␣one,
␣␣␣␣␣␣␣␣␣␣␣␣␣␣if␣none␣were␣ever␣listed.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣Lsof␣marks␣the␣end␣of␣each␣listing:␣if␣field␣output␣is␣in
␣␣␣␣␣␣␣␣␣␣␣␣␣␣progress␣(the␣-F,␣option␣has␣been␣specified),␣the␣default
␣␣␣␣␣␣␣␣␣␣␣␣␣␣marker␣is␣`m'; otherwise the default marker is
              ``========''.  The marker is followed by a NL character.

              The optional "m<fmt>" argument specifies a format for the
              marker line.  The <fmt> characters following `m'␣are
␣␣␣␣␣␣␣␣␣␣␣␣␣␣interpreted␣as␣a␣format␣specification␣to␣the␣strftime(3)
␣␣␣␣␣␣␣␣␣␣␣␣␣␣function,␣when␣both␣it␣and␣the␣localtime(3)␣function␣are
␣␣␣␣␣␣␣␣␣␣␣␣␣␣available␣in␣the␣dialect's C library.  Consult the
              strftime(3) documentation for what may appear in its
              format specification.  Note that when field output is
              requested with the -F option, <fmt> cannot contain the NL
              format, ``%n''.  Note also that when <fmt> contains spaces
              or other characters that affect the shell's␣interpretation
␣␣␣␣␣␣␣␣␣␣␣␣␣␣of␣arguments,␣<fmt>␣must␣be␣quoted␣appropriately.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣Repeat␣mode␣reduces␣lsof␣startup␣overhead,␣so␣it␣is␣more
␣␣␣␣␣␣␣␣␣␣␣␣␣␣efficient␣to␣use␣this␣mode␣than␣to␣call␣lsof␣repetitively
␣␣␣␣␣␣␣␣␣␣␣␣␣␣from␣a␣shell␣script,␣for␣example.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣To␣use␣repeat␣mode␣most␣efficiently,␣accompany␣+|-r␣with
␣␣␣␣␣␣␣␣␣␣␣␣␣␣specification␣of␣other␣lsof␣selection␣options,␣so␣the
␣␣␣␣␣␣␣␣␣␣␣␣␣␣amount␣of␣kernel␣memory␣access␣lsof␣does␣will␣be␣kept␣to␣a
␣␣␣␣␣␣␣␣␣␣␣␣␣␣minimum.␣␣Options␣that␣filter␣at␣the␣process␣level␣-␣e.g.,
␣␣␣␣␣␣␣␣␣␣␣␣␣␣-c,␣-g,␣-p,␣-u␣-␣are␣the␣most␣efficient␣selectors.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣Repeat␣mode␣is␣useful␣when␣coupled␣with␣field␣output␣(see
␣␣␣␣␣␣␣␣␣␣␣␣␣␣the␣-F,␣option␣description)␣and␣a␣supervising␣awk␣or␣Perl
␣␣␣␣␣␣␣␣␣␣␣␣␣␣script,␣or␣a␣C␣program.

␣␣␣␣␣␣␣-R␣␣␣␣␣directs␣lsof␣to␣list␣the␣Parent␣Process␣IDentification
␣␣␣␣␣␣␣␣␣␣␣␣␣␣number␣in␣the␣PPID␣column.

␣␣␣␣␣␣␣-s␣[p:s]
␣␣␣␣␣␣␣␣␣␣␣␣␣␣s␣alone␣directs␣lsof␣to␣display␣file␣size␣at␣all␣times.
␣␣␣␣␣␣␣␣␣␣␣␣␣␣It␣causes␣the␣SIZE/OFF␣output␣column␣title␣to␣be␣changed
␣␣␣␣␣␣␣␣␣␣␣␣␣␣to␣SIZE.␣␣If␣the␣file␣does␣not␣have␣a␣size,␣nothing␣is
␣␣␣␣␣␣␣␣␣␣␣␣␣␣displayed.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣The␣optional␣-s␣p:s␣form␣is␣available␣only␣for␣selected
␣␣␣␣␣␣␣␣␣␣␣␣␣␣dialects,␣and␣only␣when␣the␣-h␣or␣-?␣␣help␣output␣lists
␣␣␣␣␣␣␣␣␣␣␣␣␣␣it.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣When␣the␣optional␣form␣is␣available,␣the␣s␣may␣be␣followed
␣␣␣␣␣␣␣␣␣␣␣␣␣␣by␣a␣protocol␣name␣(p),␣either␣TCP␣or␣UDP,␣a␣colon␣(`:')
              and a comma-separated protocol state name list, the option
              causes open TCP and UDP files to be excluded if their
              state name(s) are in the list (s) preceded by a `^';␣or
␣␣␣␣␣␣␣␣␣␣␣␣␣␣included␣if␣their␣name(s)␣are␣not␣preceded␣by␣a␣`^'.

              Dialects that support this option may support only one
              protocol.  When an unsupported protocol is specified, a
              message will be displayed indicating state names for the
              protocol are unavailable.

              When an inclusion list is defined, only network files with
              state names in the list will be present in the lsof
              output.  Thus, specifying one state name means that only
              network files with that lone state name will be listed.

              Case is unimportant in the protocol or state names, but
              there may be no spaces and the colon (`:')␣separating␣the
```

protocol name (p) and the state name list (s) is required.

If only TCP and UDP files are to be listed, as controlled by the specified exclusions and inclusions, the −i option must be specified, too. If only a single protocol's files are to be listed, add its name as an argument to the −i option.

For example, to list only network files with TCP state LISTEN, use:

```
     −iTCP −sTCP:LISTEN
```

Or, **for** example, to list network files with all UDP states except Idle, use:

```
     −iUDP −sUDP:Idle
```

State names vary with UNIX dialects, so it's not possible to provide a complete list. Some common TCP state names are: CLOSED, IDLE, BOUND, LISTEN, ESTABLISHED, SYN_SENT, SYN_RCDV, ESTABLISHED, CLOSE_WAIT, FIN_WAIT1, CLOSING, LAST_ACK, FIN_WAIT_2, and TIME_WAIT. Two common UDP state names are Unbound and Idle.

See the lsof FAQ (The FAQ section gives its location.) for more information on how to use protocol state exclusion and inclusion, including examples.

The −o (without a following decimal digit count) and −s option (without a following protocol and state name list) are mutually exclusive; they can't both be specified. When neither is specified, lsof displays whatever value − size or offset − is appropriate and available **for** the **type** of file.

Since some types of files don't have true sizes − sockets, FIFOs, pipes, etc. − lsof displays for their sizes the content amounts in their associated kernel buffers, if possible.

−S [t] specifies an optional time−out seconds value for kernel functions − lstat(2), readlink(2), and stat(2) − that might otherwise deadlock. The minimum for t is two; the default, fifteen; when no value is specified, the default is used.

See the BLOCKS AND TIMEOUTS section for more information.

−T [t] controls the reporting of some TCP/TPI information, also reported by netstat(1), following the network addresses. In normal output the information appears in parentheses, each item except TCP or TPI state name identified by a keyword, followed by '=', separated from others by a single space:

```
     <TCP or TPI state name>
     QR=<read queue length>
     QS=<send queue length>
     SO=<socket options and values>
     SS=<socket states>
     TF=<TCP flags and values>
     WR=<window read length>
     WW=<window write length>
```

Not all values are reported **for** all UNIX dialects. Items values (when available) are reported after the item name and '='.

When the field output mode is **in** effect (See OUTPUT FOR OTHER PROGRAMS.) each item appears as a field with a 'T' leading character.

−T with no following key characters disables TCP/TPI information reporting.

−T with following characters selects the reporting of specific TCP/TPI information:

```
     f    selects reporting of socket options,
          states and values, and TCP flags and
          values.
     q    selects queue length reporting.
     s    selects connection state reporting.
     w    selects window size reporting.
```

Not all selections are enabled for some UNIX dialects. State may be selected for all dialects and is reported by default. The −h or −? help output for the −T option will show what selections may be used with the UNIX dialect.

When −T is used to select information − i.e., it is followed by one or more selection characters – the displaying of state is disabled by default, and it must be explicitly selected again in the characters following −T. (In effect, then, the default is equivalent to −Ts.) For example, if queue lengths and state are desired, use −Tqs.

Socket options, socket states, some socket values, TCP flags and one TCP value may be reported (when available in the UNIX dialect) in the form of the names that commonly appear after SO_, so_, SS_, TCP_ and TF_ in the dialect's header files − most often <sys/socket.h>, <sys/socketvar.h> and <netinet/tcp_var.h>. Consult those header files **for** the meaning of the flags, options, states and values.

''SO='' precedes socket options and values; ''SS='', socket states; and ''TF='', TCP flags and values.

If a flag or option has a value, the value will follow an '=' and the name –– e.g., ''SO=LINGER=5'', ''SO=QLIM=5'', ''TF=MSS=512''. The following seven values may be reported:

Name Reported	Description (Common Symbol)
KEEPALIVE	keep alive time (SO_KEEPALIVE)
LINGER	linger time (SO_LINGER)
MSS	maximum segment size (TCP_MAXSEG)
PQLEN	partial listen queue connections
QLEN	established listen queue connections
QLIM	established listen queue limit
RCVBUF	receive buffer length (SO_RCVBUF)
SNDBUF	send buffer length (SO_SNDBUF)

Details on what socket options and values, socket states, and TCP flags and values may be displayed **for** particular UNIX dialects may be found **in** the answer to the ''Why doesn't lsof report socket options, socket states, and TCP flags and values for my dialect?'' and ''Why doesn't lsof report the partial listen queue connection count **for** my dialect?'' questions **in** the lsof FAQ (The FAQ section gives its location.)

−t specifies that lsof should produce terse output with process identifiers only and no header − e.g., so that the output may be piped to **kill**(1). −t selects the −w option.

−u s selects the listing of files **for** the user whose **login** names or user ID numbers are **in** the comma−separated **set** s − e.g., ''abe'', or ''548,root''. (There should be no spaces **in** the **set**.)

Multiple **login** names or user ID numbers are joined **in** a single ORed **set** before participating **in** AND option selection.

If a **login** name or user ID is preceded by a '^', it becomes a negation – i.e., files of processes owned by the login name or user ID will never be listed. A negated login name or user ID selection is neither ANDed nor ORed with other selections; it is applied before all other selections and absolutely excludes the listing of the files of the process. For example, to direct lsof to exclude the listing of files belonging to root processes, specify ''−u^root'' or ''−u^0''.

−U selects the listing of UNIX domain socket files.

−v selects the listing of lsof version information, including: revision number; when the lsof binary was constructed; who constructed the binary and where; the name of the compiler used to construct the lsof binary; the version number of the compiler when readily available; the compiler and loader flags used to construct the lsof binary; and system information, typically the output of uname's −a option.

−V directs lsof to indicate the items it was asked to list and failed to find − **command** names, file names, Internet addresses or files, **login** names, NFS files, PIDs, PGIDs, and UIDs.

When other options are ANDed to search options, or compile−time options restrict the listing of some files, lsof may not report that it failed to find a search item when an ANDed option or compile−time option prevents the listing of the open file containing the located search item.

For example, ''lsof −V −iTCP@foobar −a −d 999'' may not report a failure to locate open files at ''TCP@foobar''

```
             and may not list any, if none have a file descriptor
             number of 999.  A similar situation arises when
             HASSECURITY and HASNOSOCKSECURITY are defined at compile
             time and they prevent the listing of open files.

       +|-w  Enables (+) or disables (-) the suppression of warning
             messages.

             The lsof builder may choose to have warning messages
             disabled or enabled by default.  The default warning
             message state is indicated in the output of the -h or -?
             option.  Disabling warning messages when they are already
             disabled or enabling them when already enabled is
             acceptable.

             The -t option selects the -w option.

       -x [fl]
             may accompany the +d and +D options to direct their
             processing to cross over symbolic links and|or file system
             mount points encountered when scanning the directory (+d)
             or directory tree (+D).

             If -x is specified by itself without a following
             parameter, cross-over processing of both symbolic links
             and file system mount points is enabled.  Note that when
             -x is specified without a parameter, the next argument
             must begin with '-' or '+'.

             The optional 'f' parameter enables file system mount point
             cross-over processing; 'l', symbolic link cross-over
             processing.

             The -x option may not be supplied without also supplying a
             +d or +D option.

       -X    This is a dialect-specific option.

           AIX:
               This IBM AIX RISC/System 6000 option requests the
               reporting of executed text file and shared library
               references.

               WARNING: because this option uses the kernel readx()
               function, its use on a busy AIX system might cause an
               application process to hang so completely that it can
               neither be killed nor stopped.  I have never seen this
               happen or had a report of its happening, but I think
               there is a remote possibility it could happen.

               By default use of readx() is disabled.  On AIX 5L and
               above lsof may need setuid-root permission to perform
               the actions this option requests.

               The lsof builder may specify that the -X option be
               restricted to processes whose real UID is root.  If that
               has been done, the -X option will not appear in the -h
               or -? help output unless the real UID of the lsof
               process is root.  The default lsof distribution allows
               any UID to specify -X, so by default it will appear in
               the help output.

               When AIX readx() use is disabled, lsof may not be able
               to report information for all text and loader file
               references, but it may also avoid exacerbating an AIX
               kernel directory search kernel error, known as the Stale
               Segment ID bug.

               The readx() function, used by lsof or any other program
               to access some sections of kernel virtual memory, can
               trigger the Stale Segment ID bug.  It can cause the
               kernel's_dir_search()_function_to_believe_erroneously
__________________that_part_of_an_in-memory_copy_of_a_file_system
__________________directory_has_been_zeroed.__Another_application_process,
__________________distinct_from_lsof,_asking_the_kernel_to_search_the
__________________directory_-_e.g.,_by_using_open(2)_-_can_cause
__________________dir_search()_to_loop_forever,_thus_hanging_the
__________________application_process.

__________________Consult_the_lsof_FAQ_(The_FAQ_section_gives_its
__________________location.)__and_the_00README_file_of_the_lsof
__________________distribution_for_a_more_complete_description_of_the
__________________Stale_Segment_ID_bug,_its_APAR,_and_methods_for_defining
__________________readx()_use_when_compiling_lsof.

____________Linux:
__________________This_Linux_option_requests_that_lsof_skip_the_reporting
__________________of_information_on_all_open_TCP,_UDP_and_UDPLITE_IPv4_and
__________________IPv6_files.

__________________This_Linux_option_is_most_useful_when_the_system_has_an
__________________extremely_large_number_of_open_TCP,_UDP_and_UDPLITE
```

________________files,_the_processing_of_whose_information_in_the
________________/proc/net/tcp*_and_/proc/net/udp*_files_would_take_lsof
________________a_long_time,_and_whose_reporting_is_not_of_interest.

________________Use_this_option_with_care_and_only_when_you_are_sure
________________that_the_information_you_want_lsof_to_display_isn't
associated with open TCP, UDP or UDPLITE socket files.

Solaris 10 and above:
This Solaris 10 and above option requests the reporting of cached paths **for** files that have been deleted − i.e., removed with rm(1) or unlink(2).

The cached path is followed by the string ‘‘ (deleted)’’ to indicate that the path by which the file was opened has been deleted.

Because intervening changes made to the path − i.e., renames with mv(1) or rename(2) − are not recorded **in** the cached path, what lsof reports is only the path by which the file was opened, not its possibly different final path.

−z [z] specifies how Solaris 10 and higher zone information is to be handled.

Without a following argument − e.g., NO z − the option specifies that zone names are to be listed **in** the ZONE output column.

The −z option may be followed by a zone name, z. That causes lsof to list only open files **for** processes **in** that zone. Multiple −z z option and argument pairs may be specified to form a list of named zones. Any open file of any process **in** any of the zones will be listed, subject to other conditions specified by other options and arguments.

−Z [Z] specifies how SELinux security contexts are to be handled. It and 'Z' field output character support are inhibited when SELinux is disabled **in** the running Linux kernel. See OUTPUT FOR OTHER PROGRAMS **for** more information on the 'Z' field output character.

Without a following argument − e.g., NO Z − the option specifies that security contexts are to be listed **in** the SECURITY−CONTEXT output column.

The −Z option may be followed by a wildcard security context name, Z. That causes lsof to list only open files **for** processes **in** that security context. Multiple −Z Z option and argument pairs may be specified to form a list of security contexts. Any open file of any process **in** any of the security contexts will be listed, subject to other conditions specified by other options and arguments. Note that Z can be A:B:C or *:B:C or A:B:* or *:*:C to match against the A:B:C context.

−− The double minus sign option is a marker that signals the end of the keyed options. It may be used, **for** example, when the first file name begins with a minus sign. It may also be used when the absence of a value **for** the last keyed option must be signified by the presence of a minus sign **in** the following option and before the start of the file names.

names These are path names of specific files to list. Symbolic links are resolved before use. The first name may be separated from the preceding options with the ‘‘−−’’ option.

If a name is the mounted−on directory of a file system or the device of the file system, lsof will list all the files open on the file system. To be considered a file system, the name must match a mounted−on directory name **in** mount(8) output, or match the name of a block device associated with a mounted−on directory name. The +|−f option may be used to force lsof to consider a name a file system identifier (+f) or a simple file (−f).

If name is a path to a directory that is not the mounted−on directory name of a file system, it is treated just as a regular file is treated − i.e., its listing is restricted to processes that have it open as a file or as a process−specific directory, such as the root or current working directory. To request that lsof look **for** open files inside a directory name, use the +d s and +D D options.

If a name is the base name of a family of multiplexed files − e.g, AIX's_/dev/pt[cs]_−_lsof_will_list_all_the
________________associated_multiplexed_files_on_the_device_that_are_open

```
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣—␣e.g.,␣/dev/pt[cs]/1,␣/dev/pt[cs]/2,␣etc.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣If␣a␣name␣is␣a␣UNIX␣domain␣socket␣name,␣lsof␣will
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣usually␣search␣for␣it␣by␣the␣characters␣of␣the␣name
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣alone␣—␣exactly␣as␣it␣is␣specified␣and␣is␣recorded␣in
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣the␣kernel␣socket␣structure.␣␣(See␣the␣next␣paragraph
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣for␣an␣exception␣to␣that␣rule␣for␣Linux.)␣␣Specifying␣a
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣relative␣path␣—␣e.g.,␣./file␣—␣in␣place␣of␣the␣file's
                absolute path − e.g., /tmp/file − won't␣work␣because
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣lsof␣must␣match␣the␣characters␣you␣specify␣with␣what␣it
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣finds␣in␣the␣kernel␣UNIX␣domain␣socket␣structures.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣If␣a␣name␣is␣a␣Linux␣UNIX␣domain␣socket␣name,␣in␣one
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣case␣lsof␣is␣able␣to␣search␣for␣it␣by␣its␣device␣and
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣inode␣number,␣allowing␣name␣to␣be␣a␣relative␣path.␣␣The
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣case␣requires␣that␣the␣absolute␣path␣——␣i.e.,␣one
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣beginning␣with␣a␣slash␣('/')␣be␣used␣by␣the␣process␣that
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣created␣the␣socket,␣and␣hence␣be␣stored␣in␣the
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣/proc/net/unix␣file;␣and␣it␣requires␣that␣lsof␣be␣able
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣to␣obtain␣the␣device␣and␣node␣numbers␣of␣both␣the
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣absolute␣path␣in␣/proc/net/unix␣and␣name␣via␣successful
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣stat(2)␣system␣calls.␣␣When␣those␣conditions␣are␣met,
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣lsof␣will␣be␣able␣to␣search␣for␣the␣UNIX␣domain␣socket
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣when␣some␣path␣to␣it␣is␣is␣specified␣in␣name.␣␣Thus,␣for
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣example,␣if␣the␣path␣is␣/dev/log,␣and␣an␣lsof␣search␣is
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣initiated␣when␣the␣working␣directory␣is␣/dev,␣then␣name
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣could␣be␣./log.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣If␣a␣name␣is␣none␣of␣the␣above,␣lsof␣will␣list␣any␣open
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣files␣whose␣device␣and␣inode␣match␣that␣of␣the␣specified
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣path␣name.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣If␣you␣have␣also␣specified␣the␣—b␣option,␣the␣only␣names
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣you␣may␣safely␣specify␣are␣file␣systems␣for␣which␣your
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣mount␣table␣supplies␣alternate␣device␣numbers.␣␣See␣the
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣AVOIDING␣KERNEL␣BLOCKS␣and␣ALTERNATE␣DEVICE␣NUMBERS
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣sections␣for␣more␣information.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣Multiple␣file␣names␣are␣joined␣in␣a␣single␣ORed␣set
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣before␣participating␣in␣AND␣option␣selection.
AFS
␣␣␣␣␣␣␣Lsof␣supports␣the␣recognition␣of␣AFS␣files␣for␣these␣dialects
␣␣␣␣␣␣␣(and␣AFS␣versions):

␣␣␣␣␣␣␣␣␣␣␣␣AIX␣4.1.4␣(AFS␣3.4a)
␣␣␣␣␣␣␣␣␣␣␣␣HP—UX␣9.0.5␣(AFS␣3.4a)
␣␣␣␣␣␣␣␣␣␣␣␣Linux␣1.2.13␣(AFS␣3.3)
␣␣␣␣␣␣␣␣␣␣␣␣Solaris␣2.[56]␣(AFS␣3.4a)

␣␣␣␣␣␣␣It␣may␣recognize␣AFS␣files␣on␣other␣versions␣of␣these␣dialects,
␣␣␣␣␣␣␣but␣has␣not␣been␣tested␣there.␣␣Depending␣on␣how␣AFS␣is
␣␣␣␣␣␣␣implemented,␣lsof␣may␣recognize␣AFS␣files␣in␣other␣dialects,␣or
␣␣␣␣␣␣␣may␣have␣difficulties␣recognizing␣AFS␣files␣in␣the␣supported
␣␣␣␣␣␣␣dialects.

␣␣␣␣␣␣␣Lsof␣may␣have␣trouble␣identifying␣all␣aspects␣of␣AFS␣files␣in
␣␣␣␣␣␣␣supported␣dialects␣when␣AFS␣kernel␣support␣is␣implemented␣via
␣␣␣␣␣␣␣dynamic␣modules␣whose␣addresses␣do␣not␣appear␣in␣the␣kernel's
       variable name list.  In that case, lsof may have to guess at the
       identity of AFS files, and might not be able to obtain volume
       information from the kernel that is needed for calculating AFS
       volume node numbers.  When lsof can't␣compute␣volume␣node
␣␣␣␣␣␣␣numbers,␣it␣reports␣blank␣in␣the␣NODE␣column.

␣␣␣␣␣␣␣The␣—A␣A␣option␣is␣available␣in␣some␣dialect␣implementations␣of
␣␣␣␣␣␣␣lsof␣for␣specifying␣the␣name␣list␣file␣where␣dynamic␣module
␣␣␣␣␣␣␣kernel␣addresses␣may␣be␣found.␣␣When␣this␣option␣is␣available,␣it
␣␣␣␣␣␣␣will␣be␣listed␣in␣the␣lsof␣help␣output,␣presented␣in␣response␣to
␣␣␣␣␣␣␣the␣—h␣or␣—?

␣␣␣␣␣␣␣See␣the␣lsof␣FAQ␣(The␣FAQ␣section␣gives␣its␣location.)␣␣for␣more
␣␣␣␣␣␣␣information␣about␣dynamic␣modules,␣their␣symbols,␣and␣how␣they
␣␣␣␣␣␣␣affect␣lsof␣options.

␣␣␣␣␣␣␣Because␣AFS␣path␣lookups␣don't seem to participate in the
       kernel's␣name␣cache␣operations,␣lsof␣can't identify path name
       components for AFS files.
SECURITY
       Lsof has three features that may cause security concerns.  First,
       its default compilation mode allows anyone to list all open files
       with it.  Second, by default it creates a user−readable and
       user−writable device cache file in the home directory of the real
       user ID that executes lsof.  (The list−all−open−files and device
       cache features may be disabled when lsof is compiled.)  Third,
       its −k and —m options name alternate kernel name list or memory
       files.

       Restricting the listing of all open files is controlled by the
       compile−time HASSECURITY and HASNOSOCKSECURITY options.  When
       HASSECURITY is defined, lsof will allow only the root user to
       list all open files.  The non−root user may list only open files
       of processes with the same user IDentification number as the real
```

```
        user ID number of the lsof process (the one that its user logged
        on with).

        However, if HASSECURITY and HASNOSOCKSECURITY are both defined,
        anyone may list open socket files, provided they are selected
        with the −i option.

        When HASSECURITY is not defined, anyone may list all open files.

        Help output, presented in response to the −h or −? option, gives
        the status of the HASSECURITY and HASNOSOCKSECURITY definitions.

        See the Security section of the 00README file of the lsof
        distribution for information on building lsof with the
        HASSECURITY and HASNOSOCKSECURITY options enabled.

        Creation and use of a user−readable and user−writable device
        cache file is controlled by the compile−time HASDCACHE option.
        See the DEVICE CACHE FILE section and the sections that follow it
        for details on how its path is formed.  For security
        considerations it is important to note that in the default lsof
        distribution, if the real user ID under which lsof is executed is
        root, the device cache file will be written in root's_home
_______directory_−_e.g.,_/_or_/root.__When_HASDCACHE_is_not_defined,
_______lsof_does_not_write_or_attempt_to_read_a_device_cache_file.

_______When_HASDCACHE_is_defined,_the_lsof_help_output,_presented_in
_______response_to_the_−h,_−D?,_or_−?__options,_will_provide_device
_______cache_file_handling_information.__When_HASDCACHE_is_not_defined,
_______the_−h_or_−?__output_will_have_no_−D_option_description.

_______Before_you_decide_to_disable_the_device_cache_file_feature_−
_______enabling_it_improves_the_performance_of_lsof_by_reducing_the
_______startup_overhead_of_examining_all_the_nodes_in_/dev_(or_/devices)
_______−_read_the_discussion_of_it_in_the_00DCACHE_file_of_the_lsof
_______distribution_and_the_lsof_FAQ_(The_FAQ_section_gives_its
_______location.)

_______WHEN_IN_DOUBT,_YOU_CAN_TEMPORARILY_DISABLE_THE_USE_OF_THE_DEVICE
_______CACHE_FILE_WITH_THE_−Di_OPTION.

_______When_lsof_user_declares_alternate_kernel_name_list_or_memory
_______files_with_the_−k_and_−m_options,_lsof_checks_the_user's
        authority to read them with access(2).  This is intended to
        prevent whatever special power lsof's_modes_might_confer_on_it
_______from_letting_it_read_files_not_normally_accessible_via_the
_______authority_of_the_real_user_ID.
OUTPUT
_______This_section_describes_the_information_lsof_lists_for_each_open
_______file.__See_the_OUTPUT_FOR_OTHER_PROGRAMS_section_for_additional
_______information_on_output_that_can_be_processed_by_another_program.

_______Lsof_only_outputs_printable_(declared_so_by_isprint(3))_8_bit
_______characters.__Non−printable_characters_are_printed_in_one_of_three
_______forms:_the_C_``\[bfrnt]''_form;_the_control_character_`^' form
        (e.g., ``^@''); or hexadecimal leading ``\x'' form (e.g.,
        ``\xab'').  Space is non−printable in the COMMAND column
        (``\x20'') and printable elsewhere.

        For some dialects − if HASSETLOCALE is defined in the dialect's
_______machine.h_header_file_−_lsof_will_print_the_extended_8_bit
_______characters_of_a_language_locale.__The_lsof_process_must_be
_______supplied_a_language_locale_environment_variable_(e.g.,_LANG)
_______whose_value_represents_a_known_language_locale_in_which_the
_______extended_characters_are_considered_printable_by_isprint(3).
_______Otherwise_lsof_considers_the_extended_characters_non−printable
_______and_prints_them_according_to_its_rules_for_non−printable
_______characters,_stated_above.__Consult_your_dialect's setlocale(3)
        man page for the names of other environment variables that may be
        used in place of LANG − e.g., LC_ALL, LC_CTYPE, etc.

        Lsof's_language_locale_support_for_a_dialect_also_covers_wide
_______characters_−_e.g.,_UTF−8_−_when_HASSETLOCALE_and_HASWIDECHAR_are
_______defined_in_the_dialect's machine.h header file, and when a
        suitable language locale has been defined in the appropriate
        environment variable for the lsof process.  Wide characters are
        printable under those conditions if iswprint(3) reports them to
        be.  If HASSETLOCALE, HASWIDECHAR and a suitable language locale
        aren't_defined,_or_if_iswprint(3)_reports_wide_characters_that
_______aren't printable, lsof considers the wide characters
        non−printable and prints each of their 8 bits according to its
        rules for non−printable characters, stated above.

        Consult the answers to the "Language_locale_support" questions in
        the lsof FAQ (The FAQ section gives its location.) for more
        information.

        Lsof dynamically sizes the output columns each time it runs,
        guaranteeing that each column is a minimum size.  It also
        guarantees that each column is separated from its predecessor by
        at least one space.
```

COMMAND

contains the first nine characters of the name of the UNIX **command** associated with the process. If a non−zero w value is specified to the +c w option, the column contains the first w characters of the name of the UNIX **command** associated with the process up to the limit of characters supplied to lsof by the UNIX dialect. (See the description of the +c w **command** or the lsof FAQ **for** more information. The FAQ section gives its location.)

If w is less than the length of the column title, ''COMMAND'', it will be raised to that length.

If a zero w value is specified to the +c w option, the column contains all the characters of the name of the UNIX **command** associated with the process.

All **command** name characters maintained by the kernel **in** its structures are displayed **in** field output when the **command** name descriptor ('c') is specified. See the OUTPUT FOR OTHER COMMANDS section for information on selecting field output and the associated command name descriptor.

PID is the Process IDentification number of the process.

TID is the task (thread) IDentification number, if task (thread) reporting is supported by the dialect and a task (thread) is being listed. (If help output − i.e., the output of the −h or −? options − shows this option, then task (thread) reporting is supported by the dialect.)

A blank TID column in Linux indicates a process − i.e., a non−task.

TASKCMD

is the task command name. Generally this will be the same as the process named in the COMMAND column, but some task implementations (e.g., Linux) permit a task to change its command name.

The TASKCMD column width is subject to the same size limitation as the COMMAND column.

ZONE is the Solaris 10 and higher zone name. This column must be selected with the −z option.

SECURITY−CONTEXT

is the SELinux security context. This column must be selected with the −Z option. Note that the −Z option is inhibited when SELinux is disabled in the running Linux kernel.

PPID is the Parent Process IDentification number of the process. It is only displayed when the −R option has been specified.

PGID is the process group IDentification number associated with the process. It is only displayed when the −g option has been specified.

USER is the user ID number or login name of the user to whom the process belongs, usually the same as reported by ps(1). However, on Linux USER is the user ID number or login that owns the directory in /proc where lsof finds information about the process. Usually that is the same value reported by ps(1), but may differ when the process has changed its effective user ID. (See the −l option description for information on when a user ID number or login name is displayed.)

FD is the File Descriptor number of the file or:

cwd current working directory;
Lnn library references (AIX);
err FD information error (see NAME column);
jld jail directory (FreeBSD);
ltx shared library text (code and data);
Mxx hex memory−mapped type number xx.
m86 DOS Merge mapped file;
mem memory−mapped file;
mmap memory−mapped device;
pd parent directory;
rtd root directory;
tr kernel trace file (OpenBSD);
txt program text (code and data);
v86 VP/ix mapped file;

FD is followed by one of these characters, describing the mode under which the file is open:

r for read access;

```
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣w␣for␣write␣access;
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣u␣for␣read␣and␣write␣access;
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣space␣if␣mode␣unknown␣and␣no␣lock
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣character␣follows;
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣`-' if mode unknown and lock
                        character follows.

              The mode character is followed by one of these lock
              characters, describing the type of lock applied to the
              file:

                   N for a Solaris NFS lock of unknown type;
                   r for read lock on part of the file;
                   R for a read lock on the entire file;
                   w for a write lock on part of the file;
                   W for a write lock on the entire file;
                   u for a read and write lock of any length;
                   U for a lock of unknown type;
                   x for an SCO OpenServer Xenix lock on part      of
              the file;
                   X for an SCO OpenServer Xenix lock on the entire
              file;
                   space if there is no lock.

              See the LOCKS section for more information on the lock
              information character.

              The FD column contents constitutes a single field for
              parsing in post-processing scripts.

       TYPE   is the type of the node associated with the file - e.g.,
              GDIR, GREG, VDIR, VREG, etc.

              or ``IPv4'' for an IPv4 socket;

              or ``IPv6'' for an open IPv6 network file - even if its
              address is IPv4, mapped in an IPv6 address;

              or ``ax25'' for a Linux AX.25 socket;

              or ``inet'' for an Internet domain socket;

              or ``lla'' for a HP-UX link level access file;

              or ``rte'' for an AF_ROUTE socket;

              or ``sock'' for a socket of unknown domain;

              or ``unix'' for a UNIX domain socket;

              or ``x.25'' for an HP-UX x.25 socket;

              or ``BLK'' for a block special file;

              or ``CHR'' for a character special file;

              or ``DEL'' for a Linux map file that has been deleted;

              or ``DIR'' for a directory;

              or ``DOOR'' for a VDOOR file;

              or ``FIFO'' for a FIFO special file;

              or ``KQUEUE'' for a BSD style kernel event queue file;

              or ``LINK'' for a symbolic link file;

              or ``MPB'' for a multiplexed block file;

              or ``MPC'' for a multiplexed character file;

              or ``NOFD'' for a Linux /proc/<PID>/fd directory that
              can't␣be␣opened␣--␣the␣directory␣path␣appears␣in␣the␣NAME
␣␣␣␣␣␣␣␣␣␣␣␣␣␣column,␣followed␣by␣an␣error␣message;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PAS''␣for␣a␣/proc/as␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PAXV''␣for␣a␣/proc/auxv␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PCRE''␣for␣a␣/proc/cred␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PCTL''␣for␣a␣/proc␣control␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PCUR''␣for␣the␣current␣/proc␣process;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PCWD''␣for␣a␣/proc␣current␣working␣directory;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PDIR''␣for␣a␣/proc␣directory;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PETY''␣for␣a␣/proc␣executable␣type␣(etype);
```

```
␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PFD''␣for␣a␣/proc␣file␣descriptor;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PFDR''␣for␣a␣/proc␣file␣descriptor␣directory;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PFIL''␣for␣an␣executable␣/proc␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PFPR''␣for␣a␣/proc␣FP␣register␣set;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PGD''␣for␣a␣/proc/pagedata␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PGID''␣for␣a␣/proc␣group␣notifier␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PIPE''␣for␣pipes;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PLC''␣for␣a␣/proc/lwpctl␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PLDR''␣for␣a␣/proc/lpw␣directory;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PLDT''␣for␣a␣/proc/ldt␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PLPI''␣for␣a␣/proc/lpsinfo␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PLST''␣for␣a␣/proc/lstatus␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PLU''␣for␣a␣/proc/lusage␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PLWG''␣for␣a␣/proc/gwindows␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PLWI''␣for␣a␣/proc/lwpsinfo␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PLWS''␣for␣a␣/proc/lwpstatus␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PLWU''␣for␣a␣/proc/lwpusage␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PLWX''␣for␣a␣/proc/xregs␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PMAP''␣for␣a␣/proc␣map␣file␣(map);

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PMEM''␣for␣a␣/proc␣memory␣image␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PNTF''␣for␣a␣/proc␣process␣notifier␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``POBJ''␣for␣a␣/proc/object␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PODR''␣for␣a␣/proc/object␣directory;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``POLP''␣for␣an␣old␣format␣/proc␣light␣weight␣process
␣␣␣␣␣␣␣␣␣␣␣␣␣␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``POPF''␣for␣an␣old␣format␣/proc␣PID␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``POPG''␣for␣an␣old␣format␣/proc␣page␣data␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PORT''␣for␣a␣SYSV␣named␣pipe;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PREG''␣for␣a␣/proc␣register␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PRMP''␣for␣a␣/proc/rmap␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PRTD''␣for␣a␣/proc␣root␣directory;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PSGA''␣for␣a␣/proc/sigact␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PSIN''␣for␣a␣/proc/psinfo␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PSTA''␣for␣a␣/proc␣status␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PSXSEM''␣for␣a␣POSIX␣semaphore␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PSXSHM''␣for␣a␣POSIX␣shared␣memory␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PTS''␣for␣a␣/dev/pts␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PUSG''␣for␣a␣/proc/usage␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PW''␣for␣a␣/proc/watch␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``PXMP''␣for␣a␣/proc/xmap␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``REG''␣for␣a␣regular␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``SMT''␣for␣a␣shared␣memory␣transport␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``STSO''␣for␣a␣stream␣socket;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``UNNM''␣for␣an␣unnamed␣type␣file;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``XNAM''␣for␣an␣OpenServer␣Xenix␣special␣file␣of
␣␣␣␣␣␣␣␣␣␣␣␣␣␣unknown␣type;

␣␣␣␣␣␣␣␣␣␣␣␣␣␣or␣``XSEM''␣for␣an␣OpenServer␣Xenix␣semaphore␣file;
```

or ‘‘XSD’’ for an OpenServer Xenix shared data file;

or the four type number octets if the corresponding name isn't known.

FILE−ADDR
contains the kernel file structure address when f has been specified to +f;

FCT contains the file reference count from the kernel file structure when c has been specified to +f;

FILE−FLAG
when g or G has been specified to +f, this field contains the contents of the f_flag[s] member of the kernel file structure and the kernel's per−process open file flags (if available); ‘G’ causes them to be displayed **in** hexadecimal; ‘g’, as short−hand names; two lists may be displayed with entries separated by commas, the lists separated by a semicolon (‘;’); the first list may contain short−hand names **for** f_flag[s] values from the following table:

AIO	asynchronous I/O (e.g., FAIO)
AP	append
ASYN	asynchronous I/O (e.g., FASYNC)
BAS	block, **test**, and **set** **in** use
BKIU	block **if** **in** use
BL	use block offsets
BSK	block seek
CA	copy avoid
CIO	concurrent I/O
CLON	clone
CLRD	CL **read**
CR	create
DF	defer
DFI	defer IND
DFLU	data flush
DIR	direct
DLY	delay
DOCL	**do** clone
DSYN	data−only integrity
DTY	must be a directory
EVO	event only
EX	open **for** **exec**
EXCL	exclusive open
FSYN	synchronous writes
GCDF	defer during unp_gc() (AIX)
GCMK	mark during unp_gc() (AIX)
GTTY	accessed via /dev/tty
HUP	HUP **in** progress
KERN	kernel
KIOC	kernel−issued ioctl
LCK	has lock
LG	large file
MBLK	stream message block
MK	mark
MNT	mount
MSYN	multiplex synchronization
NATM	don't update atime
NB	non−blocking I/O
NBDR	no BDRM check
NBIO	SYSV non−blocking I/O
NBF	n−buffering in effect
NC	no cache
ND	no delay
NDSY	no data synchronization
NET	network
NFLK	don't follow links
NMFS	NM file system
NOTO	disable background stop
NSH	no share
NTTY	no controlling TTY
OLRM	OLR mirror
PAIO	POSIX asynchronous I/O
PP	POSIX pipe
R	**read**
RC	file and record locking cache
REV	revoked
RSH	shared **read**
RSYN	**read** synchronization
RW	**read** and write access
SL	shared lock
SNAP	cooked snapshot
SOCK	socket
SQSH	Sequent shared **set** on open
SQSV	Sequent SVM **set** on open
SQR	Sequent **set** repair on open
SQS1	Sequent full shared open
SQS2	Sequent partial shared open
STPI	stop I/O
SWR	synchronous **read**

```
                SYN       file integrity while writing
                TCPM      avoid TCP collision
                TR        truncate
                W         write
                WKUP      parallel I/O synchronization
                WTG       parallel I/O synchronization
                VH        vhangup pending
                VTXT      virtual text
                XL        exclusive lock

           this list of names was derived from F* #define's in
           dialect header files <fcntl.h>, <linux</fs.h>,
           <sys/fcntl.c>, <sys/fcntlcom.h>, and <sys/file.h>; see the
           lsof.h header file for a list showing the correspondence
           between the above short-hand names and the header file
           definitions;

           the second list (after the semicolon) may contain
           short-hand names for kernel per-process open file flags
           from this table:

                ALLC      allocated
                BR        the file has been read
                BHUP      activity stopped by SIGHUP
                BW        the file has been written
                CLSG      closing
                CX        close-on-exec (see fcntl(F_SETFD))
                LCK       lock was applied
                MP        memory-mapped
                OPIP      open pending - in progress
                RSVW      reserved wait
                SHMT      UF_FSHMAT set (AIX)
                USE       in use (multi-threaded)

      NODE-ID
           (or INODE-ADDR for some dialects) contains a unique
           identifier for the file node (usually the kernel vnode or
           inode address, but also occasionally a concatenation of
           device and node number) when n has been specified to +f;

      DEVICE contains the device numbers, separated by commas, for a
           character special, block special, regular, directory or
           NFS file;

           or ‘‘memory’’ for a memory file system node under Tru64
           UNIX;

           or the address of the private data area of a Solaris
           socket stream;

           or a kernel reference address that identifies the file
           (The kernel reference address may be used for FIFO's,_for
______________example.);

______________or_the_base_address_or_device_name_of_a_Linux_AX.25_socket
______________device.

______________Usually_only_the_lower_thirty_two_bits_of_Tru64_UNIX
______________kernel_addresses_are_displayed.

_______SIZE,_SIZE/OFF,_or_OFFSET
______________is_the_size_of_the_file_or_the_file_offset_in_bytes.__A
______________value_is_displayed_in_this_column_only_if_it_is_available.
______________Lsof_displays_whatever_value_-_size_or_offset_-_is
______________appropriate_for_the_type_of_the_file_and_the_version_of
______________lsof.

______________On_some_UNIX_dialects_lsof_can't obtain accurate or
           consistent file offset information from its kernel data
           sources, sometimes just for particular kinds of files
           (e.g., socket files.)  In other cases, files don't_have
______________true_sizes_-_e.g.,_sockets,_FIFOs,_pipes_-_so_lsof
______________displays_for_their_sizes_the_content_amounts_it_finds_in
______________their_kernel_buffer_descriptors_(e.g.,_socket_buffer_size
______________counts_or_TCP/IP_window_sizes.)__Consult_the_lsof_FAQ_(The
______________FAQ_section_gives_its_location.)__for_more_information.

______________The_file_size_is_displayed_in_decimal;_the_offset_is
______________normally_displayed_in_decimal_with_a_leading_‘‘0t’’_if_it
______________contains_8_digits_or_less;_in_hexadecimal_with_a_leading
______________‘‘0x’’_if_it_is_longer_than_8_digits.__(Consult_the_-o_o
______________option_description_for_information_on_when_8_might_default
______________to_some_other_value.)

______________Thus_the_leading_‘‘0t’’_and_‘‘0x’’_identify_an_offset_when
______________the_column_may_contain_both_a_size_and_an_offset_(i.e.,
______________its_title_is_SIZE/OFF).

______________If_the_-o_option_is_specified,_lsof_always_displays_the
______________file_offset_(or_nothing_if_no_offset_is_available)_and
______________labels_the_column_OFFSET.__The_offset_always_begins_with
______________‘‘0t’’_or_‘‘0x’’_as_described_above.
```

The lsof user can control the switch from ‘‘0t’’ to ‘‘0x’’ with the −o o option. Consult its description for more information.

If the −s option is specified, lsof always displays the file size (or nothing if no size is available) and labels the column SIZE. The −o and −s options are mutually exclusive; they can't both be specified.

For files that don't have a fixed size − e.g., don't reside on a disk device − lsof will display appropriate information about the current size or position of the file **if** it is available **in** the kernel structures that define the file.

NLINK contains the file link count when +L has been specified;

NODE is the node number of a **local** file;

or the inode number of an NFS file **in** the server host;

or the Internet protocol **type** − e.g, ‘‘TCP’’;

or ‘‘STR’’ **for** a stream;

or ‘‘CCITT’’ **for** an HP−UX x.25 socket;

or the IRQ or inode number of a Linux AX.25 socket device.

NAME is the name of the mount point and file system on which the file resides;

or the name of a file specified **in** the names option (after any symbolic links have been resolved);

or the name of a character special or block special device;

or the **local** and remote Internet addresses of a network file; the **local** host name or IP number is followed by a colon (':'), the port, ‘‘−>’’, and the two−part remote address; IP addresses may be reported as numbers or names, depending on the +|−M, −n, and −P options; colon−separated IPv6 numbers are enclosed **in** square brackets; IPv4 INADDR_ANY and IPv6 IN6_IS_ADDR_UNSPECIFIED addresses, and zero port numbers are represented by an asterisk ('*'); a UDP destination address may be followed by the amount of time elapsed since the last packet was sent to the destination; TCP, UDP and UDPLITE remote addresses may be followed by TCP/TPI information **in** parentheses − state (e.g., ‘‘(ESTABLISHED)’’, ‘‘(Unbound)’’), queue sizes, and window sizes (not all dialects) − **in** a fashion similar to what netstat(1) reports; see the −T option description or the description of the TCP/TPI field **in** OUTPUT FOR OTHER PROGRAMS **for** more information on state, queue size, and window size;

or the address or name of a UNIX domain socket, possibly including a stream clone device name, a file system object's path name, local and foreign kernel addresses, socket pair information, and a bound vnode address;

or the local and remote mount point names of an NFS file;

or ‘‘STR’’, followed by the stream name;

or a stream character device name, followed by ‘‘−>’’ and the stream name or a list of stream module names, separated by ‘‘−>’’;

or ‘‘STR:’’ followed by the SCO OpenServer stream device and module names, separated by ‘‘−>’’;

or system directory name, ‘‘ −− ’’, and as many components of the path name as lsof can find in the kernel's name cache **for** selected dialects (See the KERNEL NAME CACHE section **for** more information.);

or ‘‘PIPE−>’’, followed by a Solaris kernel pipe destination address;

or ‘‘COMMON:’’, followed by the vnode device information structure's device name, for a Solaris common vnode;

or the address family, followed by a slash (‘/’), followed by fourteen comma−separated bytes of a non−Internet raw socket address;

or the HP−UX x.25 **local** address, followed by the virtual connection number (**if** any), followed by the remote address (**if** any);

or ``(dead)'' **for** disassociated Tru64 UNIX files − typically terminal files that have been flagged with the TIOCNOTTY ioctl and closed by daemons;

or ``rd=<offset>'' and ``wr=<offset>'' **for** the values of the **read** and write offsets of a FIFO;

or ``clone n:/dev/event'' **for** SCO OpenServer file clones of the /dev/event device, where n is the minor device number of the file;

or ``(socketpair: n)'' **for** a Solaris 2.6, 8, 9 or 10 UNIX domain socket, created by the socketpair(3N) network **function**;

or ``no PCB'' **for** socket files that **do** not have a protocol block associated with them, optionally followed by ``, CANTSENDMORE'' **if** sending on the socket has been disabled, or ``, CANTRCVMORE'' **if** receiving on the socket has been disabled (e.g., by the shutdown(2) **function**);

or the **local** and remote addresses of a Linux IPX socket file **in** the form <net>:[<node>:]<port>, followed **in** parentheses by the transmit and receive queue sizes, and the connection state;

or ``dgram'' or ``stream'' **for** the **type** UnixWare 7.1.1 and above **in**−kernel UNIX domain sockets, followed by a colon (':') and the **local** path name when available, followed by ``−>'' and the remote path name or kernel socket address **in** hexadecimal when available;

or the association value, association index, endpoint value, **local** address, **local** port, remote address and remote port **for** Linux SCTP sockets;

or ``protocol: '' followed by the Linux socket's protocol attribute.

For dialects that support a ``namefs'' file system, allowing one file to be attached to another with fattach(3C), lsof will add ``(FA:<address1><direction><address2>)'' to the NAME column. <address1> and <address2> are hexadecimal vnode addresses. <direction> will be ``<−'' if <address2> has been fattach'ed to this vnode whose address is <address1>; and ``−>'' **if** <address1>, the vnode address of this vnode, has been fattach'ed to <address2>. <address1> may be omitted if it already appears in the DEVICE column.

Lsof may add two parenthetical notes to the NAME column for open Solaris 10 files: ``(?)'' if lsof considers the path name of questionable accuracy; and ``(deleted)'' if the −X option has been specified and lsof detects the open file's path name has been deleted. Consult the lsof FAQ (The FAQ section gives its location.) **for** more information on these NAME column additions.

LOCKS

Lsof can't adequately report the wide variety of UNIX dialect file locks in a single character. What it reports in a single character is a compromise between the information it finds in the kernel and the limitations of the reporting format.

Moreover, when a process holds several byte level locks on a file, lsof only reports the status of the first lock it encounters. If it is a byte level lock, then the lock character will be reported in lower case − i.e., 'r', 'w', or 'x' − rather than the upper **case** equivalent reported **for** a full file lock.

Generally lsof can only report on locks held by **local** processes on **local** files. When a **local** process sets a lock on a remotely mounted (e.g., NFS) file, the remote server host usually records the lock state. One exception is Solaris − at some patch levels of 2.3, and **in** all versions above 2.4, the Solaris kernel records information on remote locks **in** **local** structures.

Lsof has trouble reporting locks **for** some UNIX dialects. Consult the BUGS section of this manual page or the lsof FAQ (The FAQ section gives its location.) **for** more information.

OUTPUT FOR OTHER PROGRAMS

When the −F option is specified, lsof produces output that is suitable **for** processing by another program − e.g, an **awk** or Perl script, or a C program.

Each unit of information is output **in** a field that is identified with a leading character and terminated by a NL (012) (or a NUL (000) **if** the 0 (zero) field identifier character is specified.) The data of the field follows immediately after the field identification character and extends to the field terminator.

It is possible to think of field output as process and file sets. A process **set** begins with a field whose identifier is 'p' (for process IDentifier (PID)). It extends to the beginning of the

```
␣␣␣␣␣␣␣next␣PID␣field␣or␣the␣beginning␣of␣the␣first␣file␣set␣of␣the
␣␣␣␣␣␣␣process,␣whichever␣comes␣first.␣␣Included␣in␣the␣process␣set␣are
␣␣␣␣␣␣␣fields␣that␣identify␣the␣command,␣the␣process␣group
␣␣␣␣␣␣␣IDentification␣(PGID)␣number,␣the␣task␣(thread)␣ID␣(TID),␣and␣the
␣␣␣␣␣␣␣user␣ID␣(UID)␣number␣or␣login␣name.

␣␣␣␣␣␣␣A␣file␣set␣begins␣with␣a␣field␣whose␣identifier␣is␣`f' (for file
       descriptor).  It is followed by lines that describe the file's
␣␣␣␣␣␣␣access␣mode,␣lock␣state,␣type,␣device,␣size,␣offset,␣inode,
␣␣␣␣␣␣␣protocol,␣name␣and␣stream␣module␣names.␣␣It␣extends␣to␣the
␣␣␣␣␣␣␣beginning␣of␣the␣next␣file␣or␣process␣set,␣whichever␣comes␣first.

␣␣␣␣␣␣␣When␣the␣NUL␣(000)␣field␣terminator␣has␣been␣selected␣with␣the␣0
␣␣␣␣␣␣␣(zero)␣field␣identifier␣character,␣lsof␣ends␣each␣process␣and
␣␣␣␣␣␣␣file␣set␣with␣a␣NL␣(012)␣character.

␣␣␣␣␣␣␣Lsof␣always␣produces␣one␣field,␣the␣PID␣(`p') field.  All other
       fields may be declared optionally in the field identifier
       character list that follows the -F option.  When a field
       selection character identifies an item lsof does not normally
       list - e.g., PPID, selected with -R - specification of the field
       character - e.g., ``-FR'' - also selects the listing of the item.

       It is entirely possible to select a set of fields that cannot
       easily be parsed - e.g., if the field descriptor field is not
       selected, it may be difficult to identify file sets.  To help you
       avoid this difficulty, lsof supports the -F option; it selects
       the output of all fields with NL terminators (the -F0 option pair
       selects the output of all fields with NUL terminators).  For
       compatibility reasons neither -F nor -F0 select the raw device
       field.

       These are the fields that lsof will produce.  The single
       character listed first is the field identifier.

            a    file access mode
            c    process command name (all characters from proc or
                 user structure)
            C    file structure share count
            d    file's␣device␣character␣code
␣␣␣␣␣␣␣␣␣␣␣␣D␣␣␣␣file's major/minor device number (0x<hexadecimal>)
            f    file descriptor (always selected)
            F    file structure address (0x<hexadecimal>)
            G    file flaGs (0x<hexadecimal>; names if +fg follows)
            g    process group ID
            i    file's␣inode␣number
␣␣␣␣␣␣␣␣␣␣␣␣K␣␣␣␣tasK␣ID
␣␣␣␣␣␣␣␣␣␣␣␣k␣␣␣␣link␣count
␣␣␣␣␣␣␣␣␣␣␣␣l␣␣␣␣file's lock status
            L    process login name
            m    marker between repeated output
            M    the task comMand name
            n    file name, comment, Internet address
            N    node identifier (ox<hexadecimal>
            o    file's␣offset␣(decimal)
␣␣␣␣␣␣␣␣␣␣␣␣p␣␣␣␣process␣ID␣(always␣selected)
␣␣␣␣␣␣␣␣␣␣␣␣P␣␣␣␣protocol␣name
␣␣␣␣␣␣␣␣␣␣␣␣r␣␣␣␣raw␣device␣number␣(0x<hexadecimal>)
␣␣␣␣␣␣␣␣␣␣␣␣R␣␣␣␣parent␣process␣ID
␣␣␣␣␣␣␣␣␣␣␣␣s␣␣␣␣file's size (decimal)
            S    file's␣stream␣identification
␣␣␣␣␣␣␣␣␣␣␣␣t␣␣␣␣file's type
            T    TCP/TPI information, identified by prefixes (the
                 `='␣is␣part␣of␣the␣prefix):
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣QR=<read␣queue␣size>
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣QS=<send␣queue␣size>
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣SO=<socket␣options␣and␣values>␣(not␣all␣dialects)
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣SS=<socket␣states>␣(not␣all␣dialects)
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣ST=<connection␣state>
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣TF=<TCP␣flags␣and␣values>␣(not␣all␣dialects)
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣WR=<window␣read␣size>␣␣(not␣all␣dialects)
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣WW=<window␣write␣size>␣␣(not␣all␣dialects)
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣(TCP/TPI␣information␣isn't reported for all supported
                   UNIX dialects. The -h or -? help output for the
                   -T option will show what TCP/TPI reporting can be
                   requested.)
            u    process user ID
            z    Solaris 10 and higher zone name
            Z    SELinux security context (inhibited when SELinux is disabled)
            0    use NUL field terminator character in place of NL
            1-9  dialect-specific field identifiers (The output
                 of -F? identifies the information to be found
                 in dialect-specific fields.)

       You can get on-line help information on these characters and
       their descriptions by specifying the -F?  option pair.  (Escape
       the `?'␣character␣as␣your␣shell␣requires.)␣␣Additional
␣␣␣␣␣␣␣information␣on␣field␣content␣can␣be␣found␣in␣the␣OUTPUT␣section.

␣␣␣␣␣␣␣As␣an␣example,␣``-F␣pcfn''␣will␣select␣the␣process␣ID␣(`p'),
       command name (`c'),␣file␣descriptor␣(`f') and file name (`n')
␣␣␣␣␣␣␣fields␣with␣an␣NL␣field␣terminator␣character;␣``-F␣pcfn0''
```

```
␣␣␣␣␣␣␣selects␣the␣same␣output␣with␣a␣NUL␣(000)␣field␣terminator
␣␣␣␣␣␣␣character.

␣␣␣␣␣␣␣Lsof␣doesn't produce all fields for every process or file set,
       only those that are available.  Some fields are mutually
       exclusive: file device characters and file major/minor device
       numbers; file inode number and protocol name; file name and
       stream identification; file size and offset.  One or the other
       member of these mutually exclusive sets will appear in field
       output, but not both.

       Normally lsof ends each field with a NL (012) character.  The 0
       (zero) field identifier character may be specified to change the
       field terminator character to a NUL (000).  A NUL terminator may
       be easier to process with xargs(1), for example, or with programs
       whose quoting mechanisms may not easily cope with the range of
       characters in the field output.  When the NUL field terminator is
       in use, lsof ends each process and file set with a NL (012).

       Three aids to producing programs that can process lsof field
       output are included in the lsof distribution.  The first is a C
       header file, lsof_fields.h, that contains symbols for the field
       identification characters, indexes for storing them in a table,
       and explanation strings that may be compiled into programs.  Lsof
       uses this header file.

       The second aid is a set of sample scripts that process field
       output, written in awk, Perl 4, and Perl 5.  They're␣located␣in
␣␣␣␣␣␣␣the␣scripts␣subdirectory␣of␣the␣lsof␣distribution.

␣␣␣␣␣␣␣The␣third␣aid␣is␣the␣C␣library␣used␣for␣the␣lsof␣test␣suite.␣␣The
␣␣␣␣␣␣␣test␣suite␣is␣written␣in␣C␣and␣uses␣field␣output␣to␣validate␣the
␣␣␣␣␣␣␣correct␣operation␣of␣lsof.␣␣The␣library␣can␣be␣found␣in␣the
␣␣␣␣␣␣␣tests/LTlib.c␣file␣of␣the␣lsof␣distribution.␣␣The␣library␣uses
␣␣␣␣␣␣␣the␣first␣aid,␣the␣lsof_fields.h␣header␣file.
BLOCKS␣AND␣TIMEOUTS
␣␣␣␣␣␣␣Lsof␣can␣be␣blocked␣by␣some␣kernel␣functions␣that␣it␣uses␣—
␣␣␣␣␣␣␣lstat(2),␣readlink(2),␣and␣stat(2).␣␣These␣functions␣are␣stalled
␣␣␣␣␣␣␣in␣the␣kernel,␣for␣example,␣when␣the␣hosts␣where␣mounted␣NFS␣file
␣␣␣␣␣␣␣systems␣reside␣become␣inaccessible.

␣␣␣␣␣␣␣Lsof␣attempts␣to␣break␣these␣blocks␣with␣timers␣and␣child
␣␣␣␣␣␣␣processes,␣but␣the␣techniques␣are␣not␣wholly␣reliable.␣␣When␣lsof
␣␣␣␣␣␣␣does␣manage␣to␣break␣a␣block,␣it␣will␣report␣the␣break␣with␣an
␣␣␣␣␣␣␣error␣message.␣␣The␣messages␣may␣be␣suppressed␣with␣the␣−t␣and␣−w
␣␣␣␣␣␣␣options.

␣␣␣␣␣␣␣The␣default␣timeout␣value␣may␣be␣displayed␣with␣the␣−h␣or␣−?
␣␣␣␣␣␣␣option,␣and␣it␣may␣be␣changed␣with␣the␣−S␣[t]␣option.␣␣The
␣␣␣␣␣␣␣minimum␣for␣t␣is␣two␣seconds,␣but␣you␣should␣avoid␣small␣values,
␣␣␣␣␣␣␣since␣slow␣system␣responsiveness␣can␣cause␣short␣timeouts␣to
␣␣␣␣␣␣␣expire␣unexpectedly␣and␣perhaps␣stop␣lsof␣before␣it␣can␣produce
␣␣␣␣␣␣␣any␣output.

␣␣␣␣␣␣␣When␣lsof␣has␣to␣break␣a␣block␣during␣its␣access␣of␣mounted␣file
␣␣␣␣␣␣␣system␣information,␣it␣normally␣continues,␣although␣with␣less
␣␣␣␣␣␣␣information␣available␣to␣display␣about␣open␣files.

␣␣␣␣␣␣␣Lsof␣can␣also␣be␣directed␣to␣avoid␣the␣protection␣of␣timers␣and
␣␣␣␣␣␣␣child␣processes␣when␣using␣the␣kernel␣functions␣that␣might␣block
␣␣␣␣␣␣␣by␣specifying␣the␣−O␣option.␣␣While␣this␣will␣allow␣lsof␣to␣start
␣␣␣␣␣␣␣up␣with␣less␣overhead,␣it␣exposes␣lsof␣completely␣to␣the␣kernel
␣␣␣␣␣␣␣situations␣that␣might␣block␣it.␣␣Use␣this␣option␣cautiously.
AVOIDING␣KERNEL␣BLOCKS
␣␣␣␣␣␣␣You␣can␣use␣the␣−b␣option␣to␣tell␣lsof␣to␣avoid␣using␣kernel
␣␣␣␣␣␣␣functions␣that␣would␣block.␣␣Some␣cautions␣apply.

␣␣␣␣␣␣␣First,␣using␣this␣option␣usually␣requires␣that␣your␣system␣supply
␣␣␣␣␣␣␣alternate␣device␣numbers␣in␣place␣of␣the␣device␣numbers␣that␣lsof
␣␣␣␣␣␣␣would␣normally␣obtain␣with␣the␣lstat(2)␣and␣stat(2)␣kernel
␣␣␣␣␣␣␣functions.␣␣See␣the␣ALTERNATE␣DEVICE␣NUMBERS␣section␣for␣more
␣␣␣␣␣␣␣information␣on␣alternate␣device␣numbers.

␣␣␣␣␣␣␣Second,␣you␣can't specify names for lsof to locate unless they're
␣␣␣␣␣␣␣file␣system␣names.␣␣This␣is␣because␣lsof␣needs␣to␣know␣the␣device
␣␣␣␣␣␣␣and␣inode␣numbers␣of␣files␣listed␣with␣names␣in␣the␣lsof␣options,
␣␣␣␣␣␣␣and␣the␣−b␣option␣prevents␣lsof␣from␣obtaining␣them.␣␣Moreover,
␣␣␣␣␣␣␣since␣lsof␣only␣has␣device␣numbers␣for␣the␣file␣systems␣that␣have
␣␣␣␣␣␣␣alternates,␣its␣ability␣to␣locate␣files␣on␣file␣systems␣depends
␣␣␣␣␣␣␣completely␣on␣the␣availability␣and␣accuracy␣of␣the␣alternates.
␣␣␣␣␣␣␣If␣no␣alternates␣are␣available,␣or␣if␣they're incorrect, lsof
       won't␣be␣able␣to␣locate␣files␣on␣the␣named␣file␣systems.

␣␣␣␣␣␣␣Third,␣if␣the␣names␣of␣your␣file␣system␣directories␣that␣lsof
␣␣␣␣␣␣␣obtains␣from␣your␣system's mount table are symbolic links, lsof
       won't␣be␣able␣to␣resolve␣the␣links.␣␣This␣is␣because␣the␣−b
␣␣␣␣␣␣␣option␣causes␣lsof␣to␣avoid␣the␣kernel␣readlink(2)␣function␣it
␣␣␣␣␣␣␣uses␣to␣resolve␣symbolic␣links.

␣␣␣␣␣␣␣Finally,␣using␣the␣−b␣option␣causes␣lsof␣to␣issue␣warning
␣␣␣␣␣␣␣messages␣when␣it␣needs␣to␣use␣the␣kernel␣functions␣that␣the␣−b
␣␣␣␣␣␣␣option␣directs␣it␣to␣avoid.␣␣You␣can␣suppress␣these␣messages␣by
```

specifying the −w option, but if you do, you won't see the alternate device numbers reported in the warning messages.

ALTERNATE DEVICE NUMBERS

On some dialects, when lsof has to break a block because it can't get information about a mounted file system via the lstat(2) and stat(2) kernel functions, or because you specified the −b option, lsof can obtain some of the information it needs − the device number and possibly the file system type − from the system mount table. When that is possible, lsof will report the device number it obtained. (You can suppress the report by specifying the −w option.)

You can assist this process if your mount table is supported with an /etc/mtab or /etc/mnttab file that contains an options field by adding a ‘‘dev=xxxx’’ field for mount points that do not have one in their options strings. Note: you must be able to edit the file − i.e., some mount tables like recent Solaris /etc/mnttab or Linux /proc/mounts are read−only and can't be modified.

You may also be able to supply device numbers using the +m and +m m options, provided they are supported by your dialect. Check the output of lsof's −h or −? options to see if the +m and +m m options are available.

The ‘‘xxxx’’ portion of the field is the hexadecimal value of the file system's device number. (Consult the st_dev field of the output of the lstat(2) and stat(2) functions for the appropriate values for your file systems.) Here's an example from a Sun Solaris 2.6 /etc/mnttab for a file system remotely mounted via NFS:

```
     nfs  ignore,noquota,dev=2a40001
```

There's an advantage to having ‘‘dev=xxxx’’ entries in your mount table file, especially for file systems that are mounted from remote NFS servers. When a remote server crashes and you want to identify its users by running lsof on one of its clients, lsof probably won't be able to get output from the lstat(2) and stat(2) functions for the file system. If it can obtain the file system's device number from the mount table, it will be able to display the files open on the crashed NFS server.

Some dialects that do not use an ASCII /etc/mtab or /etc/mnttab file for the mount table may still provide an alternative device number in their internal mount tables. This includes AIX, Apple Darwin, FreeBSD, NetBSD, OpenBSD, and Tru64 UNIX. Lsof knows how to obtain the alternative device number for these dialects and uses it when its attempt to lstat(2) or stat(2) the file system is blocked.

If you're not sure your dialect supplies alternate device numbers for file systems from its mount table, use this lsof incantation to see if it reports any alternate device numbers:

```
      lsof −b
```

Look for standard error file warning messages that begin ‘‘assuming "dev=xxxx" from ...’’.

KERNEL NAME CACHE

Lsof is able to examine the kernel's name cache or use other kernel facilities (e.g., the ADVFS 4.x tag_to_path() function under Tru64 UNIX) on some dialects for most file system types, excluding AFS, and extract recently used path name components from it. (AFS file system path lookups don't use the kernel's name cache; some Solaris VxFS file system operations apparently don't use it, either.)

Lsof reports the complete paths it finds in the NAME column. If lsof can't report all components in a path, it reports in the NAME column the file system name, followed by a space, two ‘−’ characters, another space, and the name components it has located, separated by the ‘/’ character.

When lsof is run in repeat mode − i.e., with the −r option specified − the extent to which it can report path name components for the same file may vary from cycle to cycle. That's because other running processes can cause the kernel to remove entries from its name cache and replace them with others.

Lsof's use of the kernel name cache to identify the paths of files can lead it to report incorrect components under some circumstances. This can happen when the kernel name cache uses device and node number as a key (e.g., SCO OpenServer) and a key on a rapidly changing file system is reused. If the UNIX dialect's kernel doesn't purge the name cache entry for a file when it is unlinked, lsof may find a reference to the wrong entry in the cache. The lsof FAQ (The FAQ section gives its location.) has more information on this situation.

Lsof can report path name components for these dialects:

FreeBSD

```
              HP–UX
              Linux
              NetBSD
              NEXTSTEP
              OpenBSD
              OPENSTEP
              SCO OpenServer
              SCO|Caldera UnixWare
              Solaris
              Tru64 UNIX

        Lsof can't_report_path_name_components_for_these_dialects:

____________AIX

_______If_you_want_to_know_why_lsof_can't report path name components
        for some dialects, see the lsof FAQ (The FAQ section gives its
        location.)
DEVICE CACHE FILE
        Examining all members of the /dev (or /devices) node tree with
        stat(2) functions can be time consuming.  What's_more,_the
_______information_that_lsof_needs_–_device_number,_inode_number,_and
_______path_–_rarely_changes.

_______Consequently,_lsof_normally_maintains_an_ASCII_text_file_of
_______cached_/dev_(or_/devices)_information_(exception:_the_/proc–based
_______Linux_lsof_where_it's not needed.)  The local system
        administrator who builds lsof can control the way the device
        cache file path is formed, selecting from these options:

              Path from the –D option;
              Path from an environment variable;
              System–wide path;
              Personal path (the default);
              Personal path, modified by an environment variable.

        Consult the output of the –h, –D? , or –?  help options for the
        current state of device cache support.  The help output lists the
        default read–mode device cache file path that is in effect for
        the current invocation of lsof.  The –D? option output lists the
        read–only and write device cache file paths, the names of any
        applicable environment variables, and the personal device cache
        path format.

        Lsof can detect that the current device cache file has been
        accidentally or maliciously modified by integrity checks,
        including the computation and verification of a sixteen bit
        Cyclic Redundancy Check (CRC) sum on the file's_contents.__When
_______lsof_senses_something_wrong_with_the_file,_it_issues_a_warning
_______and_attempts_to_remove_the_current_cache_file_and_create_a_new
_______copy,_but_only_to_a_path_that_the_process_can_legitimately_write.

_______The_path_from_which_a_lsof_process_may_attempt_to_read_a_device
_______cache_file_may_not_be_the_same_as_the_path_to_which_it_can
_______legitimately_write.__Thus_when_lsof_senses_that_it_needs_to
_______update_the_device_cache_file,_it_may_choose_a_different_path_for
_______writing_it_from_the_path_from_which_it_read_an_incorrect_or
_______outdated_version.

_______If_available,_the_–Dr_option_will_inhibit_the_writing_of_a_new
_______device_cache_file.__(It's always available when specified without
        a path name argument.)

        When a new device is added to the system, the device cache file
        may need to be recreated.  Since lsof compares the mtime of the
        device cache file with the mtime and ctime of the /dev (or
        /devices) directory, it usually detects that a new device has
        been added; in that case lsof issues a warning message and
        attempts to rebuild the device cache file.

        Whenever lsof writes a device cache file, it sets its ownership
        to the real UID of the executing process, and its permission
        modes to 0600, this restricting its reading and writing to the
        file's_owner.
LSOF_PERMISSIONS_THAT_AFFECT_DEVICE_CACHE_FILE_ACCESS
_______Two_permissions_of_the_lsof_executable_affect_its_ability_to
_______access_device_cache_files.__The_permissions_are_set_by_the_local
_______system_administrator_when_lsof_is_installed.

_______The_first_and_rarer_permission_is_setuid–root.__It_comes_into
_______effect_when_lsof_is_executed;_its_effective_UID_is_then_root,
_______while_its_real_(i.e.,_that_of_the_logged–on_user)_UID_is_not.
_______The_lsof_distribution_recommends_that_versions_for_these_dialects
_______run_setuid–root.

____________HP–UX_11.11_and_11.23
____________Linux

_______The_second_and_more_common_permission_is_setgid.__It_comes_into
_______effect_when_the_effective_group_IDentification_number_(GID)_of
_______the_lsof_process_is_set_to_one_that_can_access_kernel_memory
_______devices_–_e.g.,_``kmem'',_``sys'',_or_``system''.
```

␣␣␣␣␣␣␣An␣lsof␣process␣that␣has␣setgid␣permission␣usually␣surrenders␣the
␣␣␣␣␣␣␣permission␣after␣it␣has␣accessed␣the␣kernel␣memory␣devices.␣␣When
␣␣␣␣␣␣␣it␣does␣that,␣lsof␣can␣allow␣more␣liberal␣device␣cache␣path
␣␣␣␣␣␣␣formations.␣␣The␣lsof␣distribution␣recommends␣that␣versions␣for
␣␣␣␣␣␣␣these␣dialects␣run␣setgid␣and␣be␣allowed␣to␣surrender␣setgid
␣␣␣␣␣␣␣permission.

␣␣␣␣␣␣␣␣␣␣␣␣AIX␣5.[12]␣and␣5.3−ML1
␣␣␣␣␣␣␣␣␣␣␣␣Apple␣Darwin␣7.x␣Power␣Macintosh␣systems
␣␣␣␣␣␣␣␣␣␣␣␣FreeBSD␣4.x,␣4.1x,␣5.x␣and␣[6789].x␣for␣x86−based␣systems
␣␣␣␣␣␣␣␣␣␣␣␣FreeBSD␣5.x,␣[6789].x␣and␣1[012].8 for␣Alpha,␣AMD64␣and␣Sparc64
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣based␣systems
␣␣␣␣␣␣␣␣␣␣␣␣HP−UX␣11.00
␣␣␣␣␣␣␣␣␣␣␣␣NetBSD␣1.[456],␣2.x␣and␣3.x␣for␣Alpha,␣x86,␣and␣SPARC−based
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣systems
␣␣␣␣␣␣␣␣␣␣␣␣NEXTSTEP␣3.[13]␣for␣NEXTSTEP␣architectures
␣␣␣␣␣␣␣␣␣␣␣␣OpenBSD␣2.[89]␣and␣3.[0−9]␣for␣x86−based␣systems
␣␣␣␣␣␣␣␣␣␣␣␣OPENSTEP␣4.x
␣␣␣␣␣␣␣␣␣␣␣␣SCO␣OpenServer␣Release␣5.0.6␣for␣x86−based␣systems
␣␣␣␣␣␣␣␣␣␣␣␣SCO|Caldera␣UnixWare␣7.1.4␣for␣x86−based␣systems
␣␣␣␣␣␣␣␣␣␣␣␣Solaris␣2.6,␣8,␣9␣and␣10
␣␣␣␣␣␣␣␣␣␣␣␣Tru64␣UNIX␣5.1

␣␣␣␣␣␣␣(Note:␣lsof␣for␣AIX␣5L␣and␣above␣needs␣setuid−root␣permission␣if
␣␣␣␣␣␣␣its␣−X␣option␣is␣used.)

␣␣␣␣␣␣␣Lsof␣for␣these␣dialects␣does␣not␣support␣a␣device␣cache,␣so␣the
␣␣␣␣␣␣␣permissions␣given␣to␣the␣executable␣don't apply to the device
cache file.

Linux

DEVICE CACHE FILE PATH FROM THE −D OPTION

The −D option provides limited means **for** specifying the device
cache file path. Its ? **function** will report the **read**−only and
write device cache file paths that lsof will use.

When the −D b, r, and u functions are available, you can use them
to request that the cache file be built **in** a specific location
(b[path]); **read** but not rebuilt (r[path]); or **read** and rebuilt
(u[path]). The b, r, and u functions are restricted under some
conditions. They are restricted when the lsof process is
setuid−root. The path specified with the r **function** is always
read−only, even when it is available.

The b, r, and u functions are also restricted when the lsof
process runs setgid and lsof doesn't␣surrender␣the␣setgid
␣␣␣␣␣␣␣permission.␣␣(See␣the␣LSOF␣PERMISSIONS␣THAT␣AFFECT␣DEVICE␣CACHE
␣␣␣␣␣␣␣FILE␣ACCESS␣section␣for␣a␣list␣of␣implementations␣that␣normally
␣␣␣␣␣␣␣don't surrender their setgid permission.)

A further −D **function**, i (**for** ignore), is always available.

When available, the b **function** tells lsof to **read** device
information from the kernel with the stat(2) **function** and build a
device cache file at the indicated path.

When available, the r **function** tells lsof to **read** the device
cache file, but not update it. When a path argument accompanies
−Dr, it names the device cache file path. The r **function** is
always available when it is specified without a path name
argument. If lsof is not running setuid−root and surrenders its
setgid permission, a path name argument may accompany the r
function.

When available, the u **function** tells lsof to attempt to **read** and
use the device cache file. If it can't␣read␣the␣file,␣or␣if␣it
␣␣␣␣␣␣␣finds␣the␣contents␣of␣the␣file␣incorrect␣or␣outdated,␣it␣will
␣␣␣␣␣␣␣read␣information␣from␣the␣kernel,␣and␣attempt␣to␣write␣an␣updated
␣␣␣␣␣␣␣version␣of␣the␣device␣cache␣file,␣but␣only␣to␣a␣path␣it␣considers
␣␣␣␣␣␣␣legitimate␣for␣the␣lsof␣process␣effective␣and␣real␣UIDs.

DEVICE␣CACHE␣PATH␣FROM␣AN␣ENVIRONMENT␣VARIABLE

␣␣␣␣␣␣␣Lsof's second choice **for** the device cache file is the contents of
the LSOFDEVCACHE environment variable. It avoids this choice **if**
the lsof process is setuid−root, or the real UID of the process
is root.

A further restriction applies to a device cache file path taken
from the LSOFDEVCACHE environment variable: lsof will not write a
device cache file to the path **if** the lsof process doesn't
␣␣␣␣␣␣␣surrender␣its␣setgid␣permission.␣␣(See␣the␣LSOF␣PERMISSIONS␣THAT
␣␣␣␣␣␣␣AFFECT␣DEVICE␣CACHE␣FILE␣ACCESS␣section␣for␣information␣on
␣␣␣␣␣␣␣implementations␣that␣don't surrender their setgid permission.)

The **local** system administrator can disable the use of the
LSOFDEVCACHE environment variable or change its name when
building lsof. Consult the output of −D? **for** the environment
variable's␣name.

SYSTEM−WIDE␣DEVICE␣CACHE␣PATH

␣␣␣␣␣␣␣The␣local␣system␣administrator␣may␣choose␣to␣have␣a␣system−wide
␣␣␣␣␣␣␣device␣cache␣file␣when␣building␣lsof.␣␣That␣file␣will␣generally
␣␣␣␣␣␣␣be␣constructed␣by␣a␣special␣system␣administration␣procedure␣when

_______the_system_is_booted_or_when_the_contents_of_/dev_or_/devices) _______changes.__If_defined,_it_is_lsof's third device cache file path choice.

You can tell that a system−wide device cache file is **in** effect **for** your **local** installation by examining the lsof **help** option output − i.e., the output from the −h or −? option.

Lsof will never write to the system−wide device cache file path by default. It must be explicitly named with a −D **function** **in** a root−owned procedure. Once the file has been written, the procedure must change its permission modes to 0644 (owner−**read** and owner−write, group−**read**, and other−**read**).

PERSONAL DEVICE CACHE PATH (DEFAULT)

The default device cache file path of the lsof distribution is one recorded **in** the home directory of the real UID that executes lsof. Added to the home directory is a second path component of the form .lsof_hostname.

This is lsof's_fourth_device_cache_file_path_choice,_and_is _______usually_the_default.__If_a_system−wide_device_cache_file_path_was _______defined_when_lsof_was_built,_this_fourth_choice_will_be_applied _______when_lsof_can't find the system−wide device cache file. This is the only time lsof uses two paths when reading the device cache file.

The hostname part of the second component is the base name of the executing host, as returned by gethostname(2). The base name is defined to be the characters preceding the first '.'__in_the _______gethostname(2)_output,_or_all_the_gethostname(2)_output_if_it _______contains_no_'.'.

The device cache file belongs to the user ID and is readable and writable by the user ID alone − i.e., its modes are 0600. Each distinct real user ID on a given host that executes lsof has a distinct device cache file. The hostname part of the path distinguishes device cache files **in** an NFS−mounted home directory into which device cache files are written from several different hosts.

The personal device cache file path formed by this method represents a device cache file that lsof will attempt to **read**, and will attempt to write should it not exist or should its contents be incorrect or outdated.

The −Dr option without a path name argument will inhibit the writing of a new device cache file.

The −D? option will list the format specification **for** constructing the personal device cache file. The conversions used **in** the format specification are described **in** the 00DCACHE file of the lsof distribution.

MODIFIED PERSONAL DEVICE CACHE PATH

If this option is defined by the **local** system administrator when lsof is built, the LSOFPERSDCPATH environment variable contents may be used to add a component of the personal device cache file path.

The LSOFPERSDCPATH variable contents are inserted **in** the path at the place marked by the **local** system administrator with the ''%p'' conversion **in** the HASPERSDC format specification of the dialect's_machine.h_header_file.__(It's placed right after the home directory **in** the default lsof distribution.)

Thus, **for** example, **if** LSOFPERSDCPATH contains ''LSOF'', the home directory is ''/Homes/abe'', the host name is ''lsof.itap.purdue.edu'', and the HASPERSDC format is the default (''%h/%p.lsof_%L''), the modified personal device cache file path is:

/Homes/abe/LSOF/.lsof_vic

The LSOFPERSDCPATH environment variable is ignored when the lsof process is setuid−root or when the real UID of the process is root.

Lsof will not write to a modified personal device cache file path **if** the lsof process doesn't_surrender_setgid_permission.__(See _______the_LSOF_PERMISSIONS_THAT_AFFECT_DEVICE_CACHE_FILE_ACCESS_section _______for_a_list_of_implementations_that_normally_don't surrender their setgid permission.)

If, **for** example, you want to create a sub−directory of personal device cache file paths by using the LSOFPERSDCPATH environment variable to name it, and lsof doesn't_surrender_its_setgid _______permission,_you_will_have_to_allow_lsof_to_create_device_cache _______files_at_the_standard_personal_path_and_move_them_to_your _______subdirectory_with_shell_commands.

_______The_local_system_administrator_may:_disable_this_option_when_lsof _______is_built;_change_the_name_of_the_environment_variable_from _______LSOFPERSDCPATH_to_something_else;_change_the_HASPERSDC_format_to _______include_the_personal_path_component_in_another_place;_or_exclude _______the_personal_path_component_entirely.__Consult_the_output_of_the _______−D?__option_for_the_environment_variable's name and the HASPERSDC format specification.

DIAGNOSTICS

Errors are identified with messages on the standard error file.

Lsof returns a one (1) **if** any error was detected, including the failure to locate **command** names, file names, Internet addresses or files, **login** names, NFS files, PIDs, PGIDs, or UIDs it was asked to list. If the −V option is specified, lsof will indicate the search items it failed to list.

It returns a zero (0) **if** no errors were detected and **if** it was able to list some information about all the specified search arguments.

When lsof cannot open access to /dev (or /devices) or one of its subdirectories, or get information on a file **in** them with stat(2), it issues a warning message and continues. That lsof will issue warning messages about inaccessible files **in** /dev (or /devices) is indicated **in** its **help** output − requested with the −h or >B −? options − with the message:

```
Inaccessible /dev warnings are enabled.
```

The warning message may be suppressed with the −w option. It may also have been suppressed by the system administrator when lsof was compiled by the setting of the WARNDEVACCESS definition. In this **case**, the output from the **help** options will include the message:

```
Inaccessible /dev warnings are disabled.
```

Inaccessible device warning messages usually disappear after lsof has created a working device cache file.

EXAMPLES

For a more extensive **set** of examples, documented more fully, see the 00QUICKSTART file of the lsof distribution.

To list all open files, use:

```
lsof
```

To list all open Internet, x.25 (HP−UX), and UNIX domain files, use:

```
lsof −i −U
```

To list all open IPv4 network files **in** use by the process whose PID is 1234, use:

```
lsof −i 4 −a −p 1234
```

Presuming the UNIX dialect supports IPv6, to list only open IPv6 network files, use:

```
lsof −i 6
```

To list all files using any protocol on ports 513, 514, or 515 of host wonderland.cc.purdue.edu, use:

```
lsof −i @wonderland.cc.purdue.edu:513−515
```

To list all files using any protocol on any port of mace.cc.purdue.edu (cc.purdue.edu is the default domain), use:

```
lsof −i @mace
```

To list all open files **for login** name ‘‘abe’’, or user ID 1234, or process 456, or process 123, or process 789, use:

```
lsof −p 456,123,789 −u 1234,abe
```

To list all open files on device /dev/hd4, use:

```
lsof /dev/hd4
```

To find the process that has /u/abe/foo open, use:

```
lsof /u/abe/foo
```

To send a SIGHUP to the processes that have /u/abe/bar open, use:

```
kill −HUP ‘lsof −t /u/abe/bar‘
```

To find any open file, including an open UNIX domain socket file, with the name /dev/log, use:

```
lsof /dev/log
```

To find processes with open files on the NFS file system named

```
       /nfs/mount/point whose server is inaccessible, and presuming your
       mount table supplies the device number for /nfs/mount/point, use:

              lsof −b /nfs/mount/point

       To do the preceding search with warning messages suppressed, use:

              lsof −bw /nfs/mount/point

       To ignore the device cache file, use:

              lsof −Di

       To obtain PID and command name field output for each process,
       file descriptor, file device number, and file inode number for
       each file of each process, use:

              lsof −FpcfDi

       To list the files at descriptors 1 and 3 of every process running
       the lsof command for login ID ‘‘abe’’ every 10 seconds, use:

              lsof −c lsof −a −d 1 −d 3 −u abe −r10

       To list the current working directory of processes running a
       command that is exactly four characters long and has an 'o' or
       'O' in character three, use this regular expression form of the
       −c c option:

              lsof −c /^..o.$/i −a −d cwd

       To find an IP version 4 socket file by its associated numeric
       dot−form address, use:

              lsof −i@128.210.15.17

       To find an IP version 6 socket file (when the UNIX dialect
       supports IPv6) by its associated numeric colon−form address, use:

              lsof −i@[0:1:2:3:4:5:6:7]

       To find an IP version 6 socket file (when the UNIX dialect
       supports IPv6) by an associated numeric colon−form address that
       has a run of zeroes in it − e.g., the loop−back address − use:

              lsof −i@[::1]

       To obtain a repeat mode marker line that contains the current
       time, use:

              lsof −rm====%T====

       To add spaces to the previous marker line, use:

              lsof −r "m====␣%T␣===="
BUGS
       Since lsof reads kernel memory in its search for open files,
       rapid changes in kernel memory may produce unpredictable results.

       When a file has multiple record locks, the lock status character
       (following the file descriptor) is derived from a test of the
       first lock structure, not from any combination of the individual
       record locks that might be described by multiple lock structures.

       Lsof can't␣search␣for␣files␣with␣restrictive␣access␣permissions
␣␣␣␣␣␣␣by␣name␣unless␣it␣is␣installed␣with␣root␣set−UID␣permission.
␣␣␣␣␣␣␣Otherwise␣it␣is␣limited␣to␣searching␣for␣files␣to␣which␣its␣user
␣␣␣␣␣␣␣or␣its␣set−GID␣group␣(if␣any)␣has␣access␣permission.

␣␣␣␣␣␣␣The␣display␣of␣the␣destination␣address␣of␣a␣raw␣socket␣(e.g.,␣for
␣␣␣␣␣␣␣ping)␣depends␣on␣the␣UNIX␣operating␣system.␣␣Some␣dialects␣store
␣␣␣␣␣␣␣the␣destination␣address␣in␣the␣raw␣socket's protocol control
       block, some do not.

       Lsof can't␣always␣represent␣Solaris␣device␣numbers␣in␣the␣same
␣␣␣␣␣␣␣way␣that␣ls(1)␣does.␣␣For␣example,␣the␣major␣and␣minor␣device
␣␣␣␣␣␣␣numbers␣that␣the␣lstat(2)␣and␣stat(2)␣functions␣report␣for␣the
␣␣␣␣␣␣␣directory␣on␣which␣CD−ROM␣files␣are␣mounted␣(typically␣/cdrom)
␣␣␣␣␣␣␣are␣not␣the␣same␣as␣the␣ones␣that␣it␣reports␣for␣the␣device␣on
␣␣␣␣␣␣␣which␣CD−ROM␣files␣are␣mounted␣(typically␣/dev/sr0).␣␣(Lsof
␣␣␣␣␣␣␣reports␣the␣directory␣numbers.)

␣␣␣␣␣␣␣The␣support␣for␣/proc␣file␣systems␣is␣available␣only␣for␣BSD␣and
␣␣␣␣␣␣␣Tru64␣UNIX␣dialects,␣Linux,␣and␣dialects␣derived␣from␣SYSV␣R4␣−
␣␣␣␣␣␣␣e.g.,␣FreeBSD,␣NetBSD,␣OpenBSD,␣Solaris,␣UnixWare.

␣␣␣␣␣␣␣Some␣/proc␣file␣items␣−␣device␣number,␣inode␣number,␣and␣file
␣␣␣␣␣␣␣size␣−␣are␣unavailable␣in␣some␣dialects.␣␣Searching␣for␣files␣in
␣␣␣␣␣␣␣a␣/proc␣file␣system␣may␣require␣that␣the␣full␣path␣name␣be
␣␣␣␣␣␣␣specified.

␣␣␣␣␣␣␣No␣text␣(txt)␣file␣descriptors␣are␣displayed␣for␣Linux␣processes.
```

```
        All entries for files other than the current working directory,
        the root directory, and numerical file descriptors are labeled
        mem descriptors.

        Lsof can't search for Tru64 UNIX named pipes by name, because
        their kernel implementation of lstat(2) returns an improper
        device number for a named pipe.

        Lsof can't report fully or correctly on HP-UX 9.01, 10.20, and
        11.00 locks because of insufficient access to kernel data or
        errors in the kernel data.  See the lsof FAQ (The FAQ section
        gives its location.)  for details.

        The AIX SMT file type is a fabrication.  It's made up for file
        structures whose type (15) isn't defined in the AIX
        /usr/include/sys/file.h header file.  One way to create such file
        structures is to run X clients with the DISPLAY variable set to
        ``:0.0''.

        The +|-f[cfgGn] option is not supported under /proc-based Linux
        lsof, because it doesn't read kernel structures from kernel
        memory.
ENVIRONMENT
        Lsof may access these environment variables.

        LANG   defines a language locale.  See setlocale(3) for the names
               of other variables that can be used in place of LANG -
               e.g., LC_ALL, LC_TYPE, etc.

        LSOFDEVCACHE
               defines the path to a device cache file.  See the DEVICE
               CACHE PATH FROM AN ENVIRONMENT VARIABLE section for more
               information.

        LSOFPERSDCPATH
               defines the middle component of a modified personal device
               cache file path.  See the MODIFIED PERSONAL DEVICE CACHE
               PATH section for more information.
FAQ
        Frequently-asked questions and their answers (an FAQ) are
        available in the 00FAQ file of the lsof distribution.

        That file is also available via anonymous ftp from
        lsof.itap.purdue.edu at pub/tools/unix/lsofFAQ.  The URL is:

               ftp://lsof.itap.purdue.edu/pub/tools/unix/lsof/FAQ
FILES
        /dev/kmem
               kernel virtual memory device

        /dev/mem
               physical memory device

        /dev/swap
               system paging device

        .lsof_hostname
               lsof's device cache file (The suffix, hostname, is the
               first component of the host's name returned by
               gethostname(2).)
AUTHORS
        Lsof was written by Victor A.Abell <abe@purdue.edu> of Purdue
        University.  Many others have contributed to lsof.  They're
        listed in the 00CREDITS file of the lsof distribution.
DISTRIBUTION
        The latest distribution of lsof is available via anonymous ftp
        from the host lsof.itap.purdue.edu.  You'll find the lsof
        distribution in the pub/tools/unix/lsof directory.

        You can also use this URL:

               ftp://lsof.itap.purdue.edu/pub/tools/unix/lsof

        Lsof is also mirrored elsewhere.  When you access
        lsof.itap.purdue.edu and change to its pub/tools/unix/lsof
        directory, you'll be given a list of some mirror sites.  The
        pub/tools/unix/lsof directory also contains a more complete list
        in its mirrors file.  Use mirrors with caution - not all mirrors
        always have the latest lsof revision.

        Some pre-compiled Lsof executables are available on
        lsof.itap.purdue.edu, but their use is discouraged - it's better
        that you build your own from the sources.  If you feel you must
        use a pre-compiled executable, please read the cautions that
        appear in the README files of the pub/tools/unix/lsof/binaries
        subdirectories and in the 00* files of the distribution.

        More information on the lsof distribution can be found in its
        README.lsof_<version> file.  If you intend to get the lsof
        distribution and build it, please read README.lsof_<version> and
        the other 00* files of the distribution before sending questions
        to the author.
```

```
SEE ALSO
        Not all the following manual pages may exist in every UNIX
        dialect to which lsof has been ported.

        access(2), awk(1), crash(1), fattach(3C), ff(1), fstat(8),
        fuser(1), gethostname(2), isprint(3), kill(1), localtime(3),
        lstat(2), modload(8), mount(8), netstat(1), ofiles(8L), perl(1),
        ps(1), readlink(2), setlocale(3), stat(2), strftime(3), time(2),
        uname(1).
COLOPHON
        This page is part of the lsof (LiSt Open Files) project.
        Information about the project can be found at
        http://people.freebsd.org/~abe/.  If you have a bug report for
        this manual page, send it to abe@purdue.edu.  This page was
        obtained from the tarball lsof_4.91_src.tar fetched from
        ftp://ftp.fu-berlin.de/pub/unix/tools/lsof/lsof.tar.gz on
        2024-06-14.  If you discover any rendering problems in this HTML
        version of the page, or you believe there is a better or more up-
        to-date source for the page, or you have corrections or
        improvements to the information in this COLOPHON (which is not
        part of the original manual page), send a mail to
        man-pages@man7.org

                                 Revision-4.91                          LSOF(8)
```

3.6 `objdump`: Display Information From Object Files

```
NAME
        objdump - display information from object files
SYNOPSIS
        objdump [-a|--archive-headers]
                [-b bfdname|--target=bfdname]
                [-C|--demangle[=style] ]
                [-d|--disassemble[=symbol]]
                [-D|--disassemble-all]
                [-z|--disassemble-zeroes]
                [-EB|-EL|--endian={big | little }]
                [-f|--file-headers]
                [-F|--file-offsets]
                [--file-start-context]
                [-g|--debugging]
                [-e|--debugging-tags]
                [-h|--section-headers|--headers]
                [-i|--info]
                [-j section|--section=section]
                [-l|--line-numbers]
                [-S|--source]
                [--source-comment[=text]]
                [-m machine|--architecture=machine]
                [-M options|--disassembler-options=options]
                [-p|--private-headers]
                [-P options|--private=options]
                [-r|--reloc]
                [-R|--dynamic-reloc]
                [-s|--full-contents]
                [-Z|--decompress]
                [-W[lLiaprmfFsoORtUuTgAck]|
                 --dwarf[=rawline,=decodedline,=info,=abbrev,=pubnames,=aranges,=macro,=frames,=frames-interp,=str,=str-off
                [-WK|--dwarf=follow-links]
                [-WN|--dwarf=no-follow-links]
                [-wD|--dwarf=use-debuginfod]
                [-wE|--dwarf=do-not-use-debuginfod]
                [-L|--process-links]
                [--ctf=section]
                [--sframe=section]
                [-G|--stabs]
                [-t|--syms]
                [-T|--dynamic-syms]
                [-x|--all-headers]
                [-w|--wide]
                [--start-address=address]
                [--stop-address=address]
                [--no-addresses]
                [--prefix-addresses]
                [--[no-]show-raw-insn]
                [--adjust-vma=offset]
                [--show-all-symbols]
                [--dwarf-depth=n]
                [--dwarf-start=n]
                [--ctf-parent=section]
                [--no-recurse-limit|--recurse-limit]
                [--special-syms]
                [--prefix=prefix]
                [--prefix-strip=level]
                [--insn-width=width]
                [--visualize-jumps[=color|=extended-color|=off]
                [--disassembler-color=[off|terminal|on|extended]
                [-U method] [--unicode=method]
                [-V|--version]
                [-H|--help]
                objfile...
DESCRIPTION
       objdump displays information about one or more object files.  The
       options control what particular information to display.  This
       information is mostly useful to programmers who are working on
       the compilation tools, as opposed to programmers who just want
       their program to compile and work.

       objfile... are the object files to be examined.  When you specify
       archives, objdump shows information on each of the member object
       files.
OPTIONS
       The long and short forms of options, shown here as alternatives,
       are equivalent.  At least one option from the list
       -a,-d,-D,-e,-f,-g,-G,-h,-H,-p,-P,-r,-R,-s,-S,-t,-T,-V,-x must be
       given.

       -a
       --archive-header
           If any of the objfile files are archives, display the archive
           header information (in a format similar to ls -l).  Besides
           the information you could list with ar tv, objdump -a shows
           the object file format of each archive member.

       --adjust-vma=offset
           When dumping information, first add offset to all the section
           addresses.  This is useful if the section addresses do not
           correspond to the symbol table, which can happen when putting
           sections at particular addresses when using a format which
           can not represent section addresses, such as a.out.

       -b bfdname
       --target=bfdname
           Specify that the object-code format for the object files is
           bfdname.  This option may not be necessary; objdump can
           automatically recognize many formats.

           For example,

                   objdump -b oasys -m vax -h fu.o

           displays summary information from the section headers (-h) of
           fu.o, which is explicitly identified (-m) as a VAX object
           file in the format produced by Oasys compilers.  You can list
           the formats available with the -i option.

       -C
       --demangle[=style]
           Decode (demangle) low-level symbol names into user-level
           names.  Besides removing any initial underscore prepended by
           the system, this makes C++ function names readable.
           Different compilers have different mangling styles. The
           optional demangling style argument can be used to choose an
           appropriate demangling style for your compiler.

       --recurse-limit
       --no-recurse-limit
       --recursion-limit
       --no-recursion-limit
           Enables or disables a limit on the amount of recursion
           performed whilst demangling strings.  Since the name mangling
           formats allow for an infinite level of recursion it is
           possible to create strings whose decoding will exhaust the
           amount of stack space available on the host machine,
           triggering a memory fault.  The limit tries to prevent this
           from happening by restricting recursion to 2048 levels of
           nesting.

           The default is for this limit to be enabled, but disabling it
           may be necessary in order to demangle truly complicated
           names.  Note however that if the recursion limit is disabled
           then stack exhaustion is possible and any bug reports about
           such an event will be rejected.

       -g
       --debugging
           Display debugging information.  This attempts to parse STABS
           debugging format information stored in the file and print it
           out using a C like syntax.  If no STABS debugging was found
           this option falls back on the -W option to print any DWARF
           information in the file.

       -e
       --debugging-tags
           Like -g, but the information is generated in a format
           compatible with ctags tool.

       -d
       --disassemble
       --disassemble=symbol
```

```
           Display the assembler mnemonics for the machine instructions
           from the input file.  This option only disassembles those
           sections which are expected to contain instructions.  If the
           optional symbol argument is given, then display the assembler
           mnemonics starting at symbol.  If symbol is a function name
           then disassembly will stop at the end of the function,
           otherwise it will stop when the next symbol is encountered.
           If there are no matches for symbol then nothing will be
           displayed.

           Note if the --dwarf=follow-links option is enabled then any
           symbol tables in linked debug info files will be read in and
           used when disassembling.

       -D
       --disassemble-all
           Like -d, but disassemble the contents of all non-empty non-
           bss sections, not just those expected to contain
           instructions.  -j may be used to select specific sections.

           This option also has a subtle effect on the disassembly of
           instructions in code sections.  When option -d is in effect
           objdump will assume that any symbols present in a code
           section occur on the boundary between instructions and it
           will refuse to disassemble across such a boundary.  When
           option -D is in effect however this assumption is supressed.
           This means that it is possible for the output of -d and -D to
           differ if, for example, data is stored in code sections.

           If the target is an ARM architecture this switch also has the
           effect of forcing the disassembler to decode pieces of data
           found in code sections as if they were instructions.

           Note if the --dwarf=follow-links option is enabled then any
           symbol tables in linked debug info files will be read in and
           used when disassembling.

       --no-addresses
           When disassembling, don't␣print␣addresses␣on␣each␣line␣or␣for
␣␣␣␣␣␣␣␣␣␣␣symbols␣and␣relocation␣offsets.␣␣In␣combination␣with
␣␣␣␣␣␣␣␣␣␣␣--no-show-raw-insn␣this␣may␣be␣useful␣for␣comparing␣compiler
␣␣␣␣␣␣␣␣␣␣␣output.

␣␣␣␣␣␣␣--prefix-addresses
␣␣␣␣␣␣␣␣␣␣␣When␣disassembling,␣print␣the␣complete␣address␣on␣each␣line.
␣␣␣␣␣␣␣␣␣␣␣This␣is␣the␣older␣disassembly␣format.

␣␣␣␣␣␣␣-EB
␣␣␣␣␣␣␣-EL
␣␣␣␣␣␣␣--endian={big|little}
␣␣␣␣␣␣␣␣␣␣␣Specify␣the␣endianness␣of␣the␣object␣files.␣␣This␣only
␣␣␣␣␣␣␣␣␣␣␣affects␣disassembly.␣␣This␣can␣be␣useful␣when␣disassembling␣a
␣␣␣␣␣␣␣␣␣␣␣file␣format␣which␣does␣not␣describe␣endianness␣information,
␣␣␣␣␣␣␣␣␣␣␣such␣as␣S-records.

␣␣␣␣␣␣␣-f
␣␣␣␣␣␣␣--file-headers
␣␣␣␣␣␣␣␣␣␣␣Display␣summary␣information␣from␣the␣overall␣header␣of␣each
␣␣␣␣␣␣␣␣␣␣␣of␣the␣objfile␣files.

␣␣␣␣␣␣␣-F
␣␣␣␣␣␣␣--file-offsets
␣␣␣␣␣␣␣␣␣␣␣When␣disassembling␣sections,␣whenever␣a␣symbol␣is␣displayed,
␣␣␣␣␣␣␣␣␣␣␣also␣display␣the␣file␣offset␣of␣the␣region␣of␣data␣that␣is
␣␣␣␣␣␣␣␣␣␣␣about␣to␣be␣dumped.␣␣If␣zeroes␣are␣being␣skipped,␣then␣when
␣␣␣␣␣␣␣␣␣␣␣disassembly␣resumes,␣tell␣the␣user␣how␣many␣zeroes␣were
␣␣␣␣␣␣␣␣␣␣␣skipped␣and␣the␣file␣offset␣of␣the␣location␣from␣where␣the
␣␣␣␣␣␣␣␣␣␣␣disassembly␣resumes.␣␣When␣dumping␣sections,␣display␣the␣file
␣␣␣␣␣␣␣␣␣␣␣offset␣of␣the␣location␣from␣where␣the␣dump␣starts.

␣␣␣␣␣␣␣--file-start-context
␣␣␣␣␣␣␣␣␣␣␣Specify␣that␣when␣displaying␣interlisted␣source
␣␣␣␣␣␣␣␣␣␣␣code/disassembly␣(assumes␣-S)␣from␣a␣file␣that␣has␣not␣yet
␣␣␣␣␣␣␣␣␣␣␣been␣displayed,␣extend␣the␣context␣to␣the␣start␣of␣the␣file.

␣␣␣␣␣␣␣-h
␣␣␣␣␣␣␣--section-headers
␣␣␣␣␣␣␣--headers
␣␣␣␣␣␣␣␣␣␣␣Display␣summary␣information␣from␣the␣section␣headers␣of␣the
␣␣␣␣␣␣␣␣␣␣␣object␣file.

␣␣␣␣␣␣␣␣␣␣␣File␣segments␣may␣be␣relocated␣to␣nonstandard␣addresses,␣for
␣␣␣␣␣␣␣␣␣␣␣example␣by␣using␣the␣-Ttext,␣-Tdata,␣or␣-Tbss␣options␣to␣ld.
␣␣␣␣␣␣␣␣␣␣␣However,␣some␣object␣file␣formats,␣such␣as␣a.out,␣do␣not
␣␣␣␣␣␣␣␣␣␣␣store␣the␣starting␣address␣of␣the␣file␣segments.␣␣In␣those
␣␣␣␣␣␣␣␣␣␣␣situations,␣although␣ld␣relocates␣the␣sections␣correctly,
␣␣␣␣␣␣␣␣␣␣␣using␣objdump␣-h␣to␣list␣the␣file␣section␣headers␣cannot␣show
␣␣␣␣␣␣␣␣␣␣␣the␣correct␣addresses.␣␣Instead,␣it␣shows␣the␣usual
␣␣␣␣␣␣␣␣␣␣␣addresses,␣which␣are␣implicit␣for␣the␣target.

␣␣␣␣␣␣␣␣␣␣␣Note,␣in␣some␣cases␣it␣is␣possible␣for␣a␣section␣to␣have␣both
␣␣␣␣␣␣␣␣␣␣␣the␣READONLY␣and␣the␣NOREAD␣attributes␣set.␣␣In␣such␣cases
```

```
␣␣␣␣␣␣␣␣␣␣␣the␣NOREAD␣attribute␣takes␣precedence,␣but␣objdump␣will
␣␣␣␣␣␣␣␣␣␣␣report␣both␣since␣the␣exact␣setting␣of␣the␣flag␣bits␣might␣be
␣␣␣␣␣␣␣␣␣␣␣important.

␣␣␣␣␣␣␣-H
␣␣␣␣␣␣␣--help
␣␣␣␣␣␣␣␣␣␣␣Print␣a␣summary␣of␣the␣options␣to␣objdump␣and␣exit.

␣␣␣␣␣␣␣-i
␣␣␣␣␣␣␣--info
␣␣␣␣␣␣␣␣␣␣␣Display␣a␣list␣showing␣all␣architectures␣and␣object␣formats
␣␣␣␣␣␣␣␣␣␣␣available␣for␣specification␣with␣-b␣or␣-m.

␣␣␣␣␣␣␣-j␣name
␣␣␣␣␣␣␣--section=name
␣␣␣␣␣␣␣␣␣␣␣Display␣information␣for␣section␣name.␣␣This␣option␣may␣be
␣␣␣␣␣␣␣␣␣␣␣specified␣multiple␣times.

␣␣␣␣␣␣␣-L
␣␣␣␣␣␣␣--process-links
␣␣␣␣␣␣␣␣␣␣␣Display␣the␣contents␣of␣non-debug␣sections␣found␣in␣separate
␣␣␣␣␣␣␣␣␣␣␣debuginfo␣files␣that␣are␣linked␣to␣the␣main␣file.␣␣This
␣␣␣␣␣␣␣␣␣␣␣option␣automatically␣implies␣the␣-WK␣option,␣and␣only
␣␣␣␣␣␣␣␣␣␣␣sections␣requested␣by␣other␣command␣line␣options␣will␣be
␣␣␣␣␣␣␣␣␣␣␣displayed.

␣␣␣␣␣␣␣-l
␣␣␣␣␣␣␣--line-numbers
␣␣␣␣␣␣␣␣␣␣␣Label␣the␣display␣(using␣debugging␣information)␣with␣the
␣␣␣␣␣␣␣␣␣␣␣filename␣and␣source␣line␣numbers␣corresponding␣to␣the␣object
␣␣␣␣␣␣␣␣␣␣␣code␣or␣relocs␣shown.␣␣Only␣useful␣with␣-d,␣-D,␣or␣-r.

␣␣␣␣␣␣␣-m␣machine
␣␣␣␣␣␣␣--architecture=machine
␣␣␣␣␣␣␣␣␣␣␣Specify␣the␣architecture␣to␣use␣when␣disassembling␣object
␣␣␣␣␣␣␣␣␣␣␣files.␣␣This␣can␣be␣useful␣when␣disassembling␣object␣files
␣␣␣␣␣␣␣␣␣␣␣which␣do␣not␣describe␣architecture␣information,␣such␣as
␣␣␣␣␣␣␣␣␣␣␣S-records.␣␣You␣can␣list␣the␣available␣architectures␣with␣the
␣␣␣␣␣␣␣␣␣␣␣-i␣option.

␣␣␣␣␣␣␣␣␣␣␣For␣most␣architectures␣it␣is␣possible␣to␣supply␣an
␣␣␣␣␣␣␣␣␣␣␣architecture␣name␣and␣a␣machine␣name,␣separated␣by␣a␣colon.
␣␣␣␣␣␣␣␣␣␣␣For␣example␣foo:bar␣would␣refer␣to␣the␣bar␣machine␣type␣in
␣␣␣␣␣␣␣␣␣␣␣the␣foo␣architecture.␣␣This␣can␣be␣helpful␣if␣objdump␣has
␣␣␣␣␣␣␣␣␣␣␣been␣configured␣to␣support␣multiple␣architectures.

␣␣␣␣␣␣␣␣␣␣␣If␣the␣target␣is␣an␣ARM␣architecture␣then␣this␣switch␣has␣an
␣␣␣␣␣␣␣␣␣␣␣additional␣effect.␣␣It␣restricts␣the␣disassembly␣to␣only
␣␣␣␣␣␣␣␣␣␣␣those␣instructions␣supported␣by␣the␣architecture␣specified␣by
␣␣␣␣␣␣␣␣␣␣␣machine.␣␣If␣it␣is␣necessary␣to␣use␣this␣switch␣because␣the
␣␣␣␣␣␣␣␣␣␣␣input␣file␣does␣not␣contain␣any␣architecture␣information,␣but
␣␣␣␣␣␣␣␣␣␣␣it␣is␣also␣desired␣to␣disassemble␣all␣the␣instructions␣use
␣␣␣␣␣␣␣␣␣␣␣-marm.

␣␣␣␣␣␣␣-M␣options
␣␣␣␣␣␣␣--disassembler-options=options
␣␣␣␣␣␣␣␣␣␣␣Pass␣target␣specific␣information␣to␣the␣disassembler.␣␣Only
␣␣␣␣␣␣␣␣␣␣␣supported␣on␣some␣targets.␣␣If␣it␣is␣necessary␣to␣specify
␣␣␣␣␣␣␣␣␣␣␣more␣than␣one␣disassembler␣option␣then␣multiple␣-M␣options
␣␣␣␣␣␣␣␣␣␣␣can␣be␣used␣or␣can␣be␣placed␣together␣into␣a␣comma␣separated
␣␣␣␣␣␣␣␣␣␣␣list.

␣␣␣␣␣␣␣␣␣␣␣For␣ARC,␣dsp␣controls␣the␣printing␣of␣DSP␣instructions,␣spfp
␣␣␣␣␣␣␣␣␣␣␣selects␣the␣printing␣of␣FPX␣single␣precision␣FP␣instructions,
␣␣␣␣␣␣␣␣␣␣␣dpfp␣selects␣the␣printing␣of␣FPX␣double␣precision␣FP
␣␣␣␣␣␣␣␣␣␣␣instructions,␣quarkse_em␣selects␣the␣printing␣of␣special
␣␣␣␣␣␣␣␣␣␣␣QuarkSE-EM␣instructions,␣fpuda␣selects␣the␣printing␣of␣double
␣␣␣␣␣␣␣␣␣␣␣precision␣assist␣instructions,␣fpus␣selects␣the␣printing␣of
␣␣␣␣␣␣␣␣␣␣␣FPU␣single␣precision␣FP␣instructions,␣while␣fpud␣selects␣the
␣␣␣␣␣␣␣␣␣␣␣printing␣of␣FPU␣double␣precision␣FP␣instructions.
␣␣␣␣␣␣␣␣␣␣␣Additionally,␣one␣can␣choose␣to␣have␣all␣the␣immediates
␣␣␣␣␣␣␣␣␣␣␣printed␣in␣hexadecimal␣using␣hex.␣␣By␣default,␣the␣short
␣␣␣␣␣␣␣␣␣␣␣immediates␣are␣printed␣using␣the␣decimal␣representation,
␣␣␣␣␣␣␣␣␣␣␣while␣the␣long␣immediate␣values␣are␣printed␣as␣hexadecimal.

␣␣␣␣␣␣␣␣␣␣␣cpu=...␣allows␣one␣to␣enforce␣a␣particular␣ISA␣when
␣␣␣␣␣␣␣␣␣␣␣disassembling␣instructions,␣overriding␣the␣-m␣value␣or
␣␣␣␣␣␣␣␣␣␣␣whatever␣is␣in␣the␣ELF␣file.␣␣This␣might␣be␣useful␣to␣select
␣␣␣␣␣␣␣␣␣␣␣ARC␣EM␣or␣HS␣ISA,␣because␣architecture␣is␣same␣for␣those␣and
␣␣␣␣␣␣␣␣␣␣␣disassembler␣relies␣on␣private␣ELF␣header␣data␣to␣decide␣if
␣␣␣␣␣␣␣␣␣␣␣code␣is␣for␣EM␣or␣HS.␣␣This␣option␣might␣be␣specified
␣␣␣␣␣␣␣␣␣␣␣multiple␣times␣-␣only␣the␣latest␣value␣will␣be␣used.␣␣Valid
␣␣␣␣␣␣␣␣␣␣␣values␣are␣same␣as␣for␣the␣assembler␣-mcpu=...␣option.

␣␣␣␣␣␣␣␣␣␣␣If␣the␣target␣is␣an␣ARM␣architecture␣then␣this␣switch␣can␣be
␣␣␣␣␣␣␣␣␣␣␣used␣to␣select␣which␣register␣name␣set␣is␣used␣during
␣␣␣␣␣␣␣␣␣␣␣disassembler.␣␣Specifying␣-M␣reg-names-std␣(the␣default)␣will
␣␣␣␣␣␣␣␣␣␣␣select␣the␣register␣names␣as␣used␣in␣ARM's␣instruction set
           documentation, but with register 13 called 'sp', register 14
           called 'lr' and register 15 called 'pc'.  Specifying -M reg-
           names-apcs will select the name set used by the ARM Procedure
           Call Standard, whilst specifying -M reg-names-raw will just
```

```
use r followed by the register number.

There are also two variants on the APCS register naming
scheme enabled by -M reg-names-atpcs and -M reg-names-
special-atpcs which use the ARM/Thumb Procedure Call Standard
naming conventions.  (Either with the normal register names
or the special register names).

This option can also be used for ARM architectures to force
the disassembler to interpret all instructions as Thumb
instructions by using the switch
--disassembler-options=force-thumb.  This can be useful when
attempting to disassemble thumb code produced by other
compilers.

For AArch64 targets this switch can be used to set whether
instructions are disassembled as the most general instruction
using the -M no-aliases option or whether instruction notes
should be generated as comments in the disasssembly using -M
notes.

For the x86, some of the options duplicate functions of the
-m switch, but allow finer grained control.

"x86-64"
"i386"
"i8086"
    Select disassembly for the given architecture.

"intel"
"att"
    Select between intel syntax mode and AT&T syntax mode.

"amd64"
"intel64"
    Select between AMD64 ISA and Intel64 ISA.

"intel-mnemonic"
"att-mnemonic"
    Select between intel mnemonic mode and AT&T mnemonic
    mode.  Note: "intel-mnemonic" implies "intel" and
    "att-mnemonic" implies "att".

"addr64"
"addr32"
"addr16"
"data32"
"data16"
    Specify the default address size and operand size.  These
    five options will be overridden if "x86-64", "i386" or
    "i8086" appear later in the option string.

"suffix"
    When in AT&T mode and also for a limited set of
    instructions when in Intel mode, instructs the
    disassembler to print a mnemonic suffix even when the
    suffix could be inferred by the operands or, for certain
    instructions, the execution mode's␣defaults.

␣␣␣␣␣␣␣␣␣␣␣␣For␣PowerPC,␣the␣-M␣argument␣raw␣selects␣disasssembly␣of
␣␣␣␣␣␣␣␣␣␣␣␣hardware␣insns␣rather␣than␣aliases.␣␣For␣example,␣you␣will
␣␣␣␣␣␣␣␣␣␣␣␣see␣"rlwinm"␣rather␣than␣"clrlwi",␣and␣"addi"␣rather␣than
␣␣␣␣␣␣␣␣␣␣␣␣"li".␣␣All␣of␣the␣-m␣arguments␣for␣gas␣that␣select␣a␣CPU␣are
␣␣␣␣␣␣␣␣␣␣␣␣supported.␣␣These␣are:␣403,␣405,␣440,␣464,␣476,␣601,␣603,
␣␣␣␣␣␣␣␣␣␣␣␣604,␣620,␣7400,␣7410,␣7450,␣7455,␣750cl,␣821,␣850,␣860,␣a2,
␣␣␣␣␣␣␣␣␣␣␣␣booke,␣booke32,␣cell,␣com,␣e200z2,␣e200z4,␣e300,␣e500,
␣␣␣␣␣␣␣␣␣␣␣␣e500mc,␣e500mc64,␣e500x2,␣e5500,␣e6500,␣efs,␣power4,␣power5,
␣␣␣␣␣␣␣␣␣␣␣␣power6,␣power7,␣power8,␣power9,␣power10,␣ppc,␣ppc32,␣ppc64,
␣␣␣␣␣␣␣␣␣␣␣␣ppc64bridge,␣ppcps,␣pwr,␣pwr2,␣pwr4,␣pwr5,␣pwr5x,␣pwr6,␣pwr7,
␣␣␣␣␣␣␣␣␣␣␣␣pwr8,␣pwr9,␣pwr10,␣pwrx,␣titan,␣vle,␣and␣future.␣␣32␣and␣64
␣␣␣␣␣␣␣␣␣␣␣␣modify␣the␣default␣or␣a␣prior␣CPU␣selection,␣disabling␣and
␣␣␣␣␣␣␣␣␣␣␣␣enabling␣64-bit␣insns␣respectively.␣␣In␣addition,␣altivec,
␣␣␣␣␣␣␣␣␣␣␣␣any,␣lsp,␣htm,␣vsx,␣spe␣and␣␣spe2␣add␣capabilities␣to␣a
␣␣␣␣␣␣␣␣␣␣␣␣previous␣or␣later␣CPU␣selection.␣␣any␣will␣disassemble␣any
␣␣␣␣␣␣␣␣␣␣␣␣opcode␣known␣to␣binutils,␣but␣in␣cases␣where␣an␣opcode␣has
␣␣␣␣␣␣␣␣␣␣␣␣two␣different␣meanings␣or␣different␣arguments,␣you␣may␣not
␣␣␣␣␣␣␣␣␣␣␣␣see␣the␣disassembly␣you␣expect.␣␣If␣you␣disassemble␣without
␣␣␣␣␣␣␣␣␣␣␣␣giving␣a␣CPU␣selection,␣a␣default␣will␣be␣chosen␣from
␣␣␣␣␣␣␣␣␣␣␣␣information␣gleaned␣by␣BFD␣from␣the␣object␣files␣headers,␣but
␣␣␣␣␣␣␣␣␣␣␣␣the␣result␣again␣may␣not␣be␣as␣you␣expect.

␣␣␣␣␣␣␣␣␣␣␣␣For␣MIPS,␣this␣option␣controls␣the␣printing␣of␣instruction
␣␣␣␣␣␣␣␣␣␣␣␣mnemonic␣names␣and␣register␣names␣in␣disassembled
␣␣␣␣␣␣␣␣␣␣␣␣instructions.␣␣Multiple␣selections␣from␣the␣following␣may␣be
␣␣␣␣␣␣␣␣␣␣␣␣specified␣as␣a␣comma␣separated␣string,␣and␣invalid␣options
␣␣␣␣␣␣␣␣␣␣␣␣are␣ignored:

␣␣␣␣␣␣␣␣␣␣␣␣"no-aliases"
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣Print␣the␣'raw'␣instruction␣mnemonic␣instead␣of␣some
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣pseudo␣instruction␣mnemonic.␣␣I.e.,␣print␣'daddu'␣or␣'or'
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣instead␣of␣'move',␣'sll'␣instead␣of␣'nop',␣etc.
```

```
___________"msa"
_______________Disassemble_MSA_instructions.

___________"virt"
_______________Disassemble_the_virtualization_ASE_instructions.

___________"xpa"
_______________Disassemble_the_eXtended_Physical_Address_(XPA)_ASE
_______________instructions.

___________"gpr−names=ABI"
_______________Print_GPR_(general−purpose_register)_names_as_appropriate
_______________for_the_specified_ABI.__By_default,_GPR_names_are
_______________selected_according_to_the_ABI_of_the_binary_being
_______________disassembled.

___________"fpr−names=ABI"
_______________Print_FPR_(floating−point_register)_names_as_appropriate
_______________for_the_specified_ABI.__By_default,_FPR_numbers_are
_______________printed_rather_than_names.

___________"cp0−names=ARCH"
_______________Print_CP0_(system_control_coprocessor;_coprocessor_0)
_______________register_names_as_appropriate_for_the_CPU_or_architecture
_______________specified_by_ARCH.__By_default,_CP0_register_names_are
_______________selected_according_to_the_architecture_and_CPU_of_the
_______________binary_being_disassembled.

___________"hwr−names=ARCH"
_______________Print_HWR_(hardware_register,_used_by_the_"rdhwr"
_______________instruction)_names_as_appropriate_for_the_CPU_or
_______________architecture_specified_by_ARCH.__By_default,_HWR_names
_______________are_selected_according_to_the_architecture_and_CPU_of_the
_______________binary_being_disassembled.

___________"reg−names=ABI"
_______________Print_GPR_and_FPR_names_as_appropriate_for_the_selected
_______________ABI.

___________"reg−names=ARCH"
_______________Print_CPU−specific_register_names_(CP0_register_and_HWR
_______________names)_as_appropriate_for_the_selected_CPU_or
_______________architecture.

___________For_any_of_the_options_listed_above,_ABI_or_ARCH_may_be
___________specified_as_numeric_to_have_numbers_printed_rather_than
___________names,_for_the_selected_types_of_registers.__You_can_list_the
___________available_values_of_ABI_and_ARCH_using_the_−−help_option.

___________For_VAX,_you_can_specify_function_entry_addresses_with_−M
___________entry:0xf00ba.__You_can_use_this_multiple_times_to_properly
___________disassemble_VAX_binary_files_that_don't contain symbol tables
           (like ROM dumps).  In these cases, the function entry mask
           would otherwise be decoded as VAX instructions, which would
           probably lead the rest of the function being wrongly
           disassembled.

       −p
       −−private−headers
           Print information that is specific to the object file format.
           The exact information printed depends upon the object file
           format.  For some object file formats, no additional
           information is printed.

       −P options
       −−private=options
           Print information that is specific to the object file format.
           The argument options is a comma separated list that depends
           on the format (the lists of options is displayed with the
           help).

           For XCOFF, the available options are:

           "header"
           "aout"
           "sections"
           "syms"
           "relocs"
           "lineno,"
           "loader"
           "except"
           "typchk"
           "traceback"
           "toc"
           "ldinfo"

           For PE, the available options are:

           "header"
           "sections"

           Not all object formats support this option.  In particular
```

```
    the ELF format does not use it.

-r
--reloc
    Print the relocation entries of the file.  If used with -d or
    -D, the relocations are printed interspersed with the
    disassembly.

-R
--dynamic-reloc
    Print the dynamic relocation entries of the file.  This is
    only meaningful for dynamic objects, such as certain types of
    shared libraries.  As for -r, if used with -d or -D, the
    relocations are printed interspersed with the disassembly.

-s
--full-contents
    Display the full contents of sections, often used in
    combination with -j to request specific sections.  By default
    all non-empty non-bss sections are displayed.  By default any
    compressed section will be displayed in its compressed form.
    In order to see the contents in a decompressed form add the
    -Z option to the command line.

-S
--source
    Display source code intermixed with disassembly, if possible.
    Implies -d.

--show-all-symbols
    When disassembling, show all the symbols that match a given
    address, not just the first one.

--source-comment[=txt]
    Like the -S option, but all source code lines are displayed
    with a prefix of txt.  Typically txt will be a comment string
    which can be used to distinguish the assembler code from the
    source code.  If txt is not provided then a default string of
    "# " (hash followed by a space), will be used.

--prefix=prefix
    Specify prefix to add to the absolute paths when used with
    -S.

--prefix-strip=level
    Indicate how many initial directory names to strip off the
    hardwired absolute paths. It has no effect without
    --prefix=prefix.

--show-raw-insn
    When disassembling instructions, print the instruction in hex
    as well as in symbolic form.  This is the default except when
    --prefix-addresses is used.

--no-show-raw-insn
    When disassembling instructions, do not print the instruction
    bytes.  This is the default when --prefix-addresses is used.

--insn-width=width
    Display width bytes on a single line when disassembling
    instructions.

--visualize-jumps[=color|=extended-color|=off]
    Visualize jumps that stay inside a function by drawing ASCII
    art between the start and target addresses.  The optional
    =color argument adds color to the output using simple
    terminal colors.  Alternatively the =extended-color argument
    will add color using 8bit colors, but these might not work on
    all terminals.

    If it is necessary to disable the visualize-jumps option
    after it has previously been enabled then use
    visualize-jumps=off.

--disassembler-color=off
--disassembler-color=terminal
--disassembler-color=on|color|colour
--disassembler-color=extened|extended-color|extened-colour
    Enables or disables the use of colored syntax highlighting in
    disassembly output.  The default behaviour is determined via
    a configure time option.  Note, not all architectures support
    colored syntax highlighting, and depending upon the terminal
    used, colored output may not actually be legible.

    The on argument adds colors using simple terminal colors.

    The terminal argument does the same, but only if the output
    device is a terminal.

    The extended-color argument is similar to the on argument,
    but it uses 8-bit colors.  These may not work on all
    terminals.
```

The off argument disables colored disassembly.

−W[lLiaprmfFsoORtUuTgAckK]
−−dwarf[=rawline,=decodedline,=info,=abbrev,=pubnames,=aranges,=macro,=frames,=frames−interp,=str,=str−offsets,=loc

Displays the contents of the DWARF debug sections **in** the file, **if** any are present. Compressed debug sections are automatically decompressed (temporarily) before they are displayed. If one or more of the optional letters or words follows the switch **then** only those **type**(s) of data will be dumped. The letters and words refer to the following information:

”a”
”=abbrev”

Displays the contents of the .debug_abbrev section.

”A”
”=addr”

Displays the contents of the .debug_addr section.

”c”
”=cu_index”

Displays the contents of the .debug_cu_index and/or .debug_tu_index sections.

”f”
”=frames”

Display the raw contents of a .debug_frame section.

”F”
”=frames−interp”

Display the interpreted contents of a .debug_frame section.

”g”
”=gdb_index”

Displays the contents of the .gdb_index and/or .debug_names sections.

”i”
”=info”

Displays the contents of the .debug_info section. Note: the output from this option can also be restricted by the use of the −−dwarf−depth and −−dwarf−start options.

”k”
”=links”

Displays the contents of the .gnu_debuglink, .gnu_debugaltlink and .debug_sup sections, **if** any of them are present. Also displays any links to separate dwarf object files (dwo), **if** they are specified by the DW_AT_GNU_dwo_name or DW_AT_dwo_name attributes **in** the .debug_info section.

”K”
”=follow−links”

Display the contents of any selected debug sections that are found **in** linked, separate debug info file(s). This can result **in** multiple versions of the same debug section being displayed **if** it exists **in** more than one file.

In addition, when displaying DWARF attributes, **if** a form is found that references the separate debug info file, **then** the referenced contents will also be displayed.

Note − **in** some distributions this option is enabled by default. It can be disabled via the N debug option. The default can be chosen when configuring the binutils via the −−**enable**−follow−debug−links=yes or −−**enable**−follow−debug−links=no options. If these are not used **then** the default is to **enable** the following of debug links.

Note − **if** support **for** the debuginfod protocol was enabled when the binutils were built **then** this option will also include an attempt to contact any debuginfod servers mentioned **in** the DEBUGINFOD_URLS environment variable. This could take some time to resolve. This behaviour can be disabled via the =**do**−not−use−debuginfod debug option.

”N”
”=no−follow−links”

Disables the following of links to separate debug info files.

”D”
”=use−debuginfod”

Enables contacting debuginfod servers **if** there is a need to follow debug links. This is the default behaviour.

”E”

```
        "=do-not-use-debuginfod"
            Disables contacting debuginfod servers when there is a
            need to follow debug links.

        "l"
        "=rawline"
            Displays the contents of the .debug_line section in a raw
            format.

        "L"
        "=decodedline"
            Displays the interpreted contents of the .debug_line
            section.

        "m"
        "=macro"
            Displays the contents of the .debug_macro and/or
            .debug_macinfo sections.

        "o"
        "=loc"
            Displays the contents of the .debug_loc and/or
            .debug_loclists sections.

        "O"
        "=str-offsets"
            Displays the contents of the .debug_str_offsets section.

        "p"
        "=pubnames"
            Displays the contents of the .debug_pubnames and/or
            .debug_gnu_pubnames sections.

        "r"
        "=aranges"
            Displays the contents of the .debug_aranges section.

        "R"
        "=Ranges"
            Displays the contents of the .debug_ranges and/or
            .debug_rnglists sections.

        "s"
        "=str"
            Displays the contents of the .debug_str, .debug_line_str
            and/or .debug_str_offsets sections.

        "t"
        "=pubtype"
            Displays the contents of the .debug_pubtypes and/or
            .debug_gnu_pubtypes sections.

        "T"
        "=trace_aranges"
            Displays the contents of the .trace_aranges section.

        "u"
        "=trace_abbrev"
            Displays the contents of the .trace_abbrev section.

        "U"
        "=trace_info"
            Displays the contents of the .trace_info section.

        Note: displaying the contents of .debug_static_funcs,
        .debug_static_vars and debug_weaknames sections is not
        currently supported.

    --dwarf-depth=n
        Limit the dump of the ".debug_info" section to n children.
        This is only useful with --debug-dump=info.  The default is
        to print all DIEs; the special value 0 for n will also have
        this effect.

        With a non-zero value for n, DIEs at or deeper than n levels
        will not be printed.  The range for n is zero-based.

    --dwarf-start=n
        Print only DIEs beginning with the DIE numbered n.  This is
        only useful with --debug-dump=info.

        If specified, this option will suppress printing of any
        header information and all DIEs before the DIE numbered n.
        Only siblings and children of the specified DIE will be
        printed.

        This can be used in conjunction with --dwarf-depth.

    --dwarf-check
        Enable additional checks for consistency of Dwarf
        information.
```

--ctf[=section]
Display the contents of the specified CTF section. CTF sections themselves contain many subsections, all of which are displayed **in** order.

By default, display the name of the section named .ctf, which is the name emitted by ld.

--ctf-parent=member
If the CTF section contains ambiguously-defined types, it will consist of an archive of many CTF dictionaries, all inheriting from one dictionary containing unambiguous types. This member is by default named .ctf, like the section containing it, but it is possible to change this name using the "ctf_link_set_memb_name_changer" **function** at link time. When looking at CTF archives that have been created by a linker that uses the name changer to rename the parent archive member, --ctf-parent can be used to specify the name used **for** the parent.

--sframe[=section]
Display the contents of the specified SFrame section.

By default, display the name of the section named .sframe, which is the name emitted by ld.

-G
--stabs
Display the full contents of any sections requested. Display the contents of the .stab and .stab.index and .stab.excl sections from an ELF file. This is only useful on systems (such as Solaris 2.0) **in** which ".stab" debugging symbol-table entries are carried **in** an ELF section. In most other file formats, debugging symbol-table entries are interleaved with linkage symbols, and are visible **in** the --syms output.

--start-address=address
Start displaying data at the specified address. This affects the output of the -d, -r and -s options.

--stop-address=address
Stop displaying data at the specified address. This affects the output of the -d, -r and -s options.

-t
--syms
Print the symbol table entries of the file. This is similar to the information provided by the nm program, although the display format is different. The format of the output depends upon the format of the file being dumped, but there are two main types. One looks like this:

```
[  4](sec  3)(fl 0x00)(ty   0)(scl   3) (nx 1) 0x00000000 .bss
[  6](sec  1)(fl 0x00)(ty   0)(scl   2) (nx 0) 0x00000000 fred
```

where the number inside the square brackets is the number of the entry **in** the symbol table, the sec number is the section number, the fl value are the symbol's_flag_bits,_the_ty
___________number_is_the_symbol's **type**, the scl number is the symbol's
___________storage_class_and_the_nx_value_is_the_number_of_auxiliary
___________entries_associated_with_the_symbol.__The_last_two_fields_are
___________the_symbol's value and its name.

The other common output format, usually seen with ELF based files, looks like this:

```
00000000 l     d  .bss   00000000 .bss
00000000 g        .text  00000000 fred
```

Here the first number is the symbol's_value_(sometimes
___________referred_to_as_its_address).__The_next_field_is_actually_a
___________set_of_characters_and_spaces_indicating_the_flag_bits_that
___________are_set_on_the_symbol.__These_characters_are_described_below.
___________Next_is_the_section_with_which_the_symbol_is_associated_or
___________*ABS*_if_the_section_is_absolute_(ie_not_connected_with_any
___________section),_or_*UND*_if_the_section_is_referenced_in_the_file
___________being_dumped,_but_not_defined_there.

___________After_the_section_name_comes_another_field,_a_number,_which
___________for_common_symbols_is_the_alignment_and_for_other_symbol_is
___________the_size.__Finally_the_symbol's name is displayed.

The flag characters are divided into 7 groups as follows:

"l"
"g"
"u"
"!" The symbol is a **local** (l), global (g), unique global (u), neither global nor **local** (a space) or both global and **local** (!). A symbol can be neither **local** or global **for** a variety of reasons, e.g., because it is used **for** debugging, but it is probably an indication of a bug **if**

```
               it is ever both local and global.  Unique global symbols
               are a GNU extension to the standard set of ELF symbol
               bindings.  For such a symbol the dynamic linker will make
               sure that in the entire process there is just one symbol
               with this name and type in use.

           ”w” The symbol is weak (w) or strong (a space).

           ”C” The symbol denotes a constructor (C) or an ordinary
               symbol (a space).

           ”W” The symbol is a warning (W) or a normal symbol (a space).
               A warning symbol's␣name␣is␣a␣message␣to␣be␣displayed␣if
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣the␣symbol␣following␣the␣warning␣symbol␣is␣ever
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣referenced.

␣␣␣␣␣␣␣␣␣␣␣”I”
␣␣␣␣␣␣␣␣␣␣␣”i”␣The␣symbol␣is␣an␣indirect␣reference␣to␣another␣symbol
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣(I),␣a␣function␣to␣be␣evaluated␣during␣reloc␣processing
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣(i)␣or␣a␣normal␣symbol␣(a␣space).

␣␣␣␣␣␣␣␣␣␣␣”d”
␣␣␣␣␣␣␣␣␣␣␣”D”␣The␣symbol␣is␣a␣debugging␣symbol␣(d)␣or␣a␣dynamic␣symbol
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣(D)␣or␣a␣normal␣symbol␣(a␣space).

␣␣␣␣␣␣␣␣␣␣␣”F”
␣␣␣␣␣␣␣␣␣␣␣”f”
␣␣␣␣␣␣␣␣␣␣␣”O”␣The␣symbol␣is␣the␣name␣of␣a␣function␣(F)␣or␣a␣file␣(f)␣or
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣an␣object␣(O)␣or␣just␣a␣normal␣symbol␣(a␣space).

␣␣␣␣␣␣␣−T
␣␣␣␣␣␣␣−−dynamic−syms
␣␣␣␣␣␣␣␣␣␣␣Print␣the␣dynamic␣symbol␣table␣entries␣of␣the␣file.␣␣This␣is
␣␣␣␣␣␣␣␣␣␣␣only␣meaningful␣for␣dynamic␣objects,␣such␣as␣certain␣types␣of
␣␣␣␣␣␣␣␣␣␣␣shared␣libraries.␣␣This␣is␣similar␣to␣the␣information
␣␣␣␣␣␣␣␣␣␣␣provided␣by␣the␣nm␣program␣when␣given␣the␣−D␣(−−dynamic)
␣␣␣␣␣␣␣␣␣␣␣option.

␣␣␣␣␣␣␣␣␣␣␣The␣output␣format␣is␣similar␣to␣that␣produced␣by␣the␣−−syms
␣␣␣␣␣␣␣␣␣␣␣option,␣except␣that␣an␣extra␣field␣is␣inserted␣before␣the
␣␣␣␣␣␣␣␣␣␣␣symbol's name, giving the version information associated with
           the symbol.  If the version is the default version to be used
           when resolving unversioned references to the symbol then it's
␣␣␣␣␣␣␣␣␣␣␣displayed␣as␣is,␣otherwise␣it's put into parentheses.

       −−special−syms
           When displaying symbols include those which the target
           considers to be special in some way and which would not
           normally be of interest to the user.

       −U [d|i|l|e|x|h]
       −−unicode=[default|invalid|locale|escape|hex|highlight]
           Controls the display of UTF−8 encoded multibyte characters in
           strings.  The default (−−unicode=default) is to give them no
           special treatment.  The −−unicode=locale option displays the
           sequence in the current locale, which may or may not support
           them.  The options −−unicode=hex and −−unicode=invalid
           display them as hex byte sequences enclosed by either angle
           brackets or curly braces.

           The −−unicode=escape option displays them as escape sequences
           (\uxxxx) and the −−unicode=highlight option displays them as
           escape sequences highlighted in red (if supported by the
           output device).  The colouring is intended to draw attention
           to the presence of unicode sequences where they might not be
           expected.

       −V
       −−version
           Print the version number of objdump and exit.

       −x
       −−all−headers
           Display all available header information, including the
           symbol table and relocation entries.  Using −x is equivalent
           to specifying all of −a −f −h −p −r −t.

       −w
       −−wide
           Format some lines for output devices that have more than 80
           columns.  Also do not truncate symbol names when they are
           displayed.

       −z
       −−disassemble−zeroes
           Normally the disassembly output will skip blocks of zeroes.
           This option directs the disassembler to disassemble those
           blocks, just like any other data.

       −Z
       −−decompress
           The −Z option is meant to be used in conunction with the −s
           option.  It instructs objdump to decompress any compressed
           sections before displaying their contents.

       @file
           Read command-line options from file.  The options read are
           inserted in place of the original @file option.  If file does
           not exist, or cannot be read, then the option will be treated
           literally, and not removed.

           Options in file are separated by whitespace.  A whitespace
           character may be included in an option by surrounding the
           entire option in either single or double quotes.  Any
           character (including a backslash) may be included by
           prefixing the character to be included with a backslash.  The
           file may itself contain additional @file options; any such
           options will be processed recursively.
SEE ALSO
       nm(1), readelf(1), and the Info entries for binutils.
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binutils-2.42                   2024-06-14                    OBJDUMP(1)
```

3.7 `readelf`: Display Information On ELF Files

```
NAME
       readelf - display information about ELF files
SYNOPSIS
       readelf [-a|--all]
               [-h|--file-header]
               [-l|--program-headers|--segments]
               [-S|--section-headers|--sections]
               [-g|--section-groups]
               [-t|--section-details]
               [-e|--headers]
               [-s|--syms|--symbols]
               [--dyn-syms|--lto-syms]
               [--sym-base=[0|8|10|16]]
               [--demangle=style|--no-demangle]
               [--quiet]
               [--recurse-limit|--no-recurse-limit]
               [-U method|--unicode=method]
               [-X|--extra-sym-info|--no-extra-sym-info]
               [-n|--notes]
               [-r|--relocs]
               [-u|--unwind]
               [-d|--dynamic]
               [-V|--version-info]
               [-A|--arch-specific]
               [-D|--use-dynamic]
               [-L|--lint|--enable-checks]
               [-x <number or name>|--hex-dump=<number or name>]
               [-p <number or name>|--string-dump=<number or name>]
               [-R <number or name>|--relocated-dump=<number or name>]
               [-z|--decompress]
               [-c|--archive-index]
               [-w[lLiaprmfFsoORtUuTgAck]|
                --debug-dump[=rawline,=decodedline,=info,=abbrev,=pubnames,=aranges,=macro,=frames,=frames-interp,=str,=st
               [-wK|--debug-dump=follow-links]
               [-wN|--debug-dump=no-follow-links]
               [-wD|--debug-dump=use-debuginfod]
               [-wE|--debug-dump=do-not-use-debuginfod]
               [-P|--process-links]
               [--dwarf-depth=n]
               [--dwarf-start=n]
               [--ctf=section]
               [--ctf-parent=section]
               [--ctf-symbols=section]
```

```
                [--ctf-strings=section]
                [--sframe=section]
                [-I|--histogram]
                [-v|--version]
                [-W|--wide]
                [-T|--silent-truncation]
                [-H|--help]
                elffile...
DESCRIPTION
        readelf displays information about one or more ELF format object
        files.  The options control what particular information to
        display.

        elffile... are the object files to be examined.  32-bit and
        64-bit ELF files are supported, as are archives containing ELF
        files.

        This program performs a similar function to objdump but it goes
        into more detail and it exists independently of the BFD library,
        so if there is a bug in BFD then readelf will not be affected.
OPTIONS
        The long and short forms of options, shown here as alternatives,
        are equivalent.  At least one option besides -v or -H must be
        given.

        -a
        --all
            Equivalent to specifying --file-header, --program-headers,
            --sections, --symbols, --relocs, --dynamic, --notes,
            --version-info, --arch-specific, --unwind, --section-groups
            and --histogram.

            Note - this option does not enable --use-dynamic itself, so
            if that option is not present on the command line then
            dynamic symbols and dynamic relocs will not be displayed.

        -h
        --file-header
            Displays the information contained in the ELF header at the
            start of the file.

        -l
        --program-headers
        --segments
            Displays the information contained in the file's␣segment
␣␣␣␣␣␣␣␣␣␣␣␣headers,␣if␣it␣has␣any.

␣␣␣␣␣␣␣␣--quiet
␣␣␣␣␣␣␣␣␣␣␣␣Suppress␣"no␣symbols"␣diagnostic.

␣␣␣␣␣␣␣␣-S
␣␣␣␣␣␣␣␣--sections
␣␣␣␣␣␣␣␣--section-headers
␣␣␣␣␣␣␣␣␣␣␣␣Displays␣the␣information␣contained␣in␣the␣file's section
            headers, if it has any.

        -g
        --section-groups
            Displays the information contained in the file's␣section
␣␣␣␣␣␣␣␣␣␣␣␣groups,␣if␣it␣has␣any.

␣␣␣␣␣␣␣␣-t
␣␣␣␣␣␣␣␣--section-details
␣␣␣␣␣␣␣␣␣␣␣␣Displays␣the␣detailed␣section␣information.␣Implies␣-S.

␣␣␣␣␣␣␣␣-s
␣␣␣␣␣␣␣␣--symbols
␣␣␣␣␣␣␣␣--syms
␣␣␣␣␣␣␣␣␣␣␣␣Displays␣the␣entries␣in␣symbol␣table␣section␣of␣the␣file,␣if
␣␣␣␣␣␣␣␣␣␣␣␣it␣has␣one.␣␣If␣a␣symbol␣has␣version␣information␣associated
␣␣␣␣␣␣␣␣␣␣␣␣with␣it␣then␣this␣is␣displayed␣as␣well.␣␣The␣version␣string
␣␣␣␣␣␣␣␣␣␣␣␣is␣displayed␣as␣a␣suffix␣to␣the␣symbol␣name,␣preceded␣by␣an␣@
␣␣␣␣␣␣␣␣␣␣␣␣character.␣␣For␣example␣foo@VER_1.␣␣If␣the␣version␣is␣the
␣␣␣␣␣␣␣␣␣␣␣␣default␣version␣to␣be␣used␣when␣resolving␣unversioned
␣␣␣␣␣␣␣␣␣␣␣␣references␣to␣the␣symbol␣then␣it␣is␣displayed␣as␣a␣suffix
␣␣␣␣␣␣␣␣␣␣␣␣preceded␣by␣two␣@␣characters.␣␣For␣example␣foo@@VER_2.

␣␣␣␣␣␣␣␣--dyn-syms
␣␣␣␣␣␣␣␣␣␣␣␣Displays␣the␣entries␣in␣dynamic␣symbol␣table␣section␣of␣the
␣␣␣␣␣␣␣␣␣␣␣␣file,␣if␣it␣has␣one.␣␣The␣output␣format␣is␣the␣same␣as␣the
␣␣␣␣␣␣␣␣␣␣␣␣format␣used␣by␣the␣--syms␣option.

␣␣␣␣␣␣␣␣--lto-syms
␣␣␣␣␣␣␣␣␣␣␣␣Displays␣the␣contents␣of␣any␣LTO␣symbol␣tables␣in␣the␣file.

␣␣␣␣␣␣␣␣--sym-base=[0|8|10|16]
␣␣␣␣␣␣␣␣␣␣␣␣Forces␣the␣size␣field␣of␣the␣symbol␣table␣to␣use␣the␣given
␣␣␣␣␣␣␣␣␣␣␣␣base.␣␣Any␣unrecognized␣options␣will␣be␣treated␣as␣0.
␣␣␣␣␣␣␣␣␣␣␣␣--sym-base=0␣represents␣the␣default␣and␣legacy␣behaviour.
␣␣␣␣␣␣␣␣␣␣␣␣This␣will␣output␣sizes␣as␣decimal␣for␣numbers␣less␣than
␣␣␣␣␣␣␣␣␣␣␣␣100000.␣␣For␣sizes␣100000␣and␣greater␣hexadecimal␣notation
␣␣␣␣␣␣␣␣␣␣␣␣will␣be␣used␣with␣a␣0x␣prefix.␣␣--sym-base=8␣will␣give␣the
```

```
␣␣␣␣␣␣␣␣␣␣␣symbol␣sizes␣in␣octal.␣␣--sym-base=10␣will␣always␣give␣the
␣␣␣␣␣␣␣␣␣␣␣symbol␣sizes␣in␣decimal.␣␣--sym-base=16␣will␣always␣give␣the
␣␣␣␣␣␣␣␣␣␣␣symbol␣sizes␣in␣hexadecimal␣with␣a␣0x␣prefix.

␣␣␣␣␣␣␣-C
␣␣␣␣␣␣␣--demangle[=style]
␣␣␣␣␣␣␣␣␣␣␣Decode␣(demangle)␣low-level␣symbol␣names␣into␣user-level
␣␣␣␣␣␣␣␣␣␣␣names.␣␣This␣makes␣C++␣function␣names␣readable.␣␣Different
␣␣␣␣␣␣␣␣␣␣␣compilers␣have␣different␣mangling␣styles.␣␣The␣optional
␣␣␣␣␣␣␣␣␣␣␣demangling␣style␣argument␣can␣be␣used␣to␣choose␣an
␣␣␣␣␣␣␣␣␣␣␣appropriate␣demangling␣style␣for␣your␣compiler.

␣␣␣␣␣␣␣--no-demangle
␣␣␣␣␣␣␣␣␣␣␣Do␣not␣demangle␣low-level␣symbol␣names.␣␣This␣is␣the␣default.

␣␣␣␣␣␣␣--recurse-limit
␣␣␣␣␣␣␣--no-recurse-limit
␣␣␣␣␣␣␣--recursion-limit
␣␣␣␣␣␣␣--no-recursion-limit
␣␣␣␣␣␣␣␣␣␣␣Enables␣or␣disables␣a␣limit␣on␣the␣amount␣of␣recursion
␣␣␣␣␣␣␣␣␣␣␣performed␣whilst␣demangling␣strings.␣␣Since␣the␣name␣mangling
␣␣␣␣␣␣␣␣␣␣␣formats␣allow␣for␣an␣infinite␣level␣of␣recursion␣it␣is
␣␣␣␣␣␣␣␣␣␣␣possible␣to␣create␣strings␣whose␣decoding␣will␣exhaust␣the
␣␣␣␣␣␣␣␣␣␣␣amount␣of␣stack␣space␣available␣on␣the␣host␣machine,
␣␣␣␣␣␣␣␣␣␣␣triggering␣a␣memory␣fault.␣␣The␣limit␣tries␣to␣prevent␣this
␣␣␣␣␣␣␣␣␣␣␣from␣happening␣by␣restricting␣recursion␣to␣2048␣levels␣of
␣␣␣␣␣␣␣␣␣␣␣nesting.

␣␣␣␣␣␣␣␣␣␣␣The␣default␣is␣for␣this␣limit␣to␣be␣enabled,␣but␣disabling␣it
␣␣␣␣␣␣␣␣␣␣␣may␣be␣necessary␣in␣order␣to␣demangle␣truly␣complicated
␣␣␣␣␣␣␣␣␣␣␣names.␣␣Note␣however␣that␣if␣the␣recursion␣limit␣is␣disabled
␣␣␣␣␣␣␣␣␣␣␣then␣stack␣exhaustion␣is␣possible␣and␣any␣bug␣reports␣about
␣␣␣␣␣␣␣␣␣␣␣such␣an␣event␣will␣be␣rejected.

␣␣␣␣␣␣␣-U␣[d|i|l|e|x|h]
␣␣␣␣␣␣␣--unicode=[default|invalid|locale|escape|hex|highlight]
␣␣␣␣␣␣␣␣␣␣␣Controls␣the␣display␣of␣non-ASCII␣characters␣in␣identifier
␣␣␣␣␣␣␣␣␣␣␣names.␣␣The␣default␣(--unicode=locale␣or␣--unicode=default)
␣␣␣␣␣␣␣␣␣␣␣is␣to␣treat␣them␣as␣multibyte␣characters␣and␣display␣them␣in
␣␣␣␣␣␣␣␣␣␣␣the␣current␣locale.␣␣All␣other␣versions␣of␣this␣option␣treat
␣␣␣␣␣␣␣␣␣␣␣the␣bytes␣as␣UTF-8␣encoded␣values␣and␣attempt␣to␣interpret
␣␣␣␣␣␣␣␣␣␣␣them.␣␣If␣they␣cannot␣be␣interpreted␣or␣if␣the
␣␣␣␣␣␣␣␣␣␣␣--unicode=invalid␣option␣is␣used␣then␣they␣are␣displayed␣as␣a
␣␣␣␣␣␣␣␣␣␣␣sequence␣of␣hex␣bytes,␣encloses␣in␣curly␣parethesis
␣␣␣␣␣␣␣␣␣␣␣characters.

␣␣␣␣␣␣␣␣␣␣␣Using␣the␣--unicode=escape␣option␣will␣display␣the␣characters
␣␣␣␣␣␣␣␣␣␣␣as␣as␣unicode␣escape␣sequences␣(\uxxxx).␣␣Using␣the
␣␣␣␣␣␣␣␣␣␣␣--unicode=hex␣will␣display␣the␣characters␣as␣hex␣byte
␣␣␣␣␣␣␣␣␣␣␣sequences␣enclosed␣between␣angle␣brackets.

␣␣␣␣␣␣␣␣␣␣␣Using␣the␣--unicode=highlight␣will␣display␣the␣characters␣as
␣␣␣␣␣␣␣␣␣␣␣unicode␣escape␣sequences␣but␣it␣will␣also␣highlighted␣them␣in
␣␣␣␣␣␣␣␣␣␣␣red,␣assuming␣that␣colouring␣is␣supported␣by␣the␣output
␣␣␣␣␣␣␣␣␣␣␣device.␣␣The␣colouring␣is␣intended␣to␣draw␣attention␣to␣the
␣␣␣␣␣␣␣␣␣␣␣presence␣of␣unicode␣sequences␣when␣they␣might␣not␣be
␣␣␣␣␣␣␣␣␣␣␣expected.

␣␣␣␣␣␣␣-X
␣␣␣␣␣␣␣--extra-sym-info
␣␣␣␣␣␣␣␣␣␣␣When␣displaying␣details␣of␣symbols,␣include␣extra␣information
␣␣␣␣␣␣␣␣␣␣␣not␣normally␣presented.␣␣Currently␣this␣just␣adds␣the␣name␣of
␣␣␣␣␣␣␣␣␣␣␣the␣section␣referenced␣by␣the␣symbol's index field, if there
           is one.  In the future more information may be displayed when
           this option is enabled.

           Enabling this option effectively enables the --wide option as
           well, at least when displaying symbol information.

       --no-extra-sym-info
           Disables the effect of the --extra-sym-info option.  This is
           the default.

       -e
       --headers
           Display all the headers in the file.  Equivalent to -h -l -S.

       -n
       --notes
           Displays the contents of the NOTE segments and/or sections,
           if any.

       -r
       --relocs
           Displays the contents of the file's␣relocation␣section,␣if␣it
␣␣␣␣␣␣␣␣␣␣␣has␣one.

␣␣␣␣␣␣␣-u
␣␣␣␣␣␣␣--unwind
␣␣␣␣␣␣␣␣␣␣␣Displays␣the␣contents␣of␣the␣file's unwind section, if it has
           one.  Only the unwind sections for IA64 ELF files, as well as
           ARM unwind tables (".ARM.exidx" / ".ARM.extab") are currently
           supported.  If support is not yet implemented for your
           architecture you could try dumping the contents of the
           .eh_frames section using the --debug-dump=frames or
           --debug-dump=frames-interp options.

       -d
       --dynamic
           Displays the contents of the file's␣dynamic␣section,␣if␣it
␣␣␣␣␣␣␣␣␣␣␣has␣one.

␣␣␣␣␣␣␣-V
␣␣␣␣␣␣␣--version-info
␣␣␣␣␣␣␣␣␣␣␣Displays␣the␣contents␣of␣the␣version␣sections␣in␣the␣file,␣it
␣␣␣␣␣␣␣␣␣␣␣they␣exist.

␣␣␣␣␣␣␣-A
␣␣␣␣␣␣␣--arch-specific
␣␣␣␣␣␣␣␣␣␣␣Displays␣architecture-specific␣information␣in␣the␣file,␣if
␣␣␣␣␣␣␣␣␣␣␣there␣is␣any.

␣␣␣␣␣␣␣-D
␣␣␣␣␣␣␣--use-dynamic
␣␣␣␣␣␣␣␣␣␣␣When␣displaying␣symbols,␣this␣option␣makes␣readelf␣use␣the
␣␣␣␣␣␣␣␣␣␣␣symbol␣hash␣tables␣in␣the␣file's dynamic section, rather than
           the symbol table sections.

           When displaying relocations, this option makes readelf
           display the dynamic relocations rather than the static
           relocations.

       -L
       --lint
       --enable-checks
           Displays warning messages about possible problems with the
           file(s) being examined.  If used on its own then all of the
           contents of the file(s) will be examined.  If used with one
           of the dumping options then the warning messages will only be
           produced for the things being displayed.

       -x <number or name>
       --hex-dump=<number or name>
           Displays the contents of the indicated section as a
           hexadecimal bytes.  A number identifies a particular section
           by index in the section table; any other string identifies
           all sections with that name in the object file.

       -R <number or name>
       --relocated-dump=<number or name>
           Displays the contents of the indicated section as a
           hexadecimal bytes.  A number identifies a particular section
           by index in the section table; any other string identifies
           all sections with that name in the object file.  The contents
           of the section will be relocated before they are displayed.

       -p <number or name>
       --string-dump=<number or name>
           Displays the contents of the indicated section as printable
           strings.  A number identifies a particular section by index
           in the section table; any other string identifies all
           sections with that name in the object file.

       -z
       --decompress
           Requests that the section(s) being dumped by x, R or p
           options are decompressed before being displayed.  If the
           section(s) are not compressed then they are displayed as is.

       -c
       --archive-index
           Displays the file symbol index information contained in the
           header part of binary archives.  Performs the same function
           as the t command to ar, but without using the BFD library.

       -w[lLiaprmfFsOoRtUuTgAckK]
       --debug-dump[=rawline,=decodedline,=info,=abbrev,=pubnames,=aranges,=macro,=frames,=frames-interp,=str,=str-offsets
           Displays the contents of the DWARF debug sections in the
           file, if any are present.  Compressed debug sections are
           automatically decompressed (temporarily) before they are
           displayed.  If one or more of the optional letters or words
           follows the switch then only those type(s) of data will be
           dumped.  The letters and words refer to the following
           information:

           "a"
           "=abbrev"
               Displays the contents of the .debug_abbrev section.

           "A"
           "=addr"
               Displays the contents of the .debug_addr section.

           "c"
```

```
”=cu_index”
    Displays the contents of the .debug_cu_index and/or
    .debug_tu_index sections.

”f”
”=frames”
    Display the raw contents of a .debug_frame section.

”F”
”=frames-interp”
    Display the interpreted contents of a .debug_frame
    section.

”g”
”=gdb_index”
    Displays the contents of the .gdb_index and/or
    .debug_names sections.

”i”
”=info”
    Displays the contents of the .debug_info section.  Note:
    the output from this option can also be restricted by the
    use of the --dwarf-depth and --dwarf-start options.

”k”
”=links”
    Displays the contents of the .gnu_debuglink,
    .gnu_debugaltlink and .debug_sup sections, if any of them
    are present.  Also displays any links to separate dwarf
    object files (dwo), if they are specified by the
    DW_AT_GNU_dwo_name or DW_AT_dwo_name attributes in the
    .debug_info section.

”K”
”=follow-links”
    Display the contents of any selected debug sections that
    are found in linked, separate debug info file(s).  This
    can result in multiple versions of the same debug section
    being displayed if it exists in more than one file.

    In addition, when displaying DWARF attributes, if a form
    is found that references the separate debug info file,
    then the referenced contents will also be displayed.

    Note - in some distributions this option is enabled by
    default.  It can be disabled via the N debug option.  The
    default can be chosen when configuring the binutils via
    the --enable-follow-debug-links=yes or
    --enable-follow-debug-links=no options.  If these are not
    used then the default is to enable the following of debug
    links.

    Note - if support for the debuginfod protocol was enabled
    when the binutils were built then this option will also
    include an attempt to contact any debuginfod servers
    mentioned in the DEBUGINFOD_URLS environment variable.
    This could take some time to resolve.  This behaviour can
    be disabled via the =do-not-use-debuginfod debug option.

”N”
”=no-follow-links”
    Disables the following of links to separate debug info
    files.

”D”
”=use-debuginfod”
    Enables contacting debuginfod servers if there is a need
    to follow debug links.  This is the default behaviour.

”E”
”=do-not-use-debuginfod”
    Disables contacting debuginfod servers when there is a
    need to follow debug links.

”l”
”=rawline”
    Displays the contents of the .debug_line section in a raw
    format.

”L”
”=decodedline”
    Displays the interpreted contents of the .debug_line
    section.

”m”
”=macro”
    Displays the contents of the .debug_macro and/or
    .debug_macinfo sections.

”o”
”=loc”
    Displays the contents of the .debug_loc and/or
```

```
          .debug_loclists sections.

      "O"
      "=str-offsets"
          Displays the contents of the .debug_str_offsets section.

      "p"
      "=pubnames"
          Displays the contents of the .debug_pubnames and/or
          .debug_gnu_pubnames sections.

      "r"
      "=aranges"
          Displays the contents of the .debug_aranges section.

      "R"
      "=Ranges"
          Displays the contents of the .debug_ranges and/or
          .debug_rnglists sections.

      "s"
      "=str"
          Displays the contents of the .debug_str, .debug_line_str
          and/or .debug_str_offsets sections.

      "t"
      "=pubtype"
          Displays the contents of the .debug_pubtypes and/or
          .debug_gnu_pubtypes sections.

      "T"
      "=trace_aranges"
          Displays the contents of the .trace_aranges section.

      "u"
      "=trace_abbrev"
          Displays the contents of the .trace_abbrev section.

      "U"
      "=trace_info"
          Displays the contents of the .trace_info section.

      Note: displaying the contents of .debug_static_funcs,
      .debug_static_vars and debug_weaknames sections is not
      currently supported.

--dwarf-depth=n
      Limit the dump of the ".debug_info" section to n children.
      This is only useful with --debug-dump=info.  The default is
      to print all DIEs; the special value 0 for n will also have
      this effect.

      With a non-zero value for n, DIEs at or deeper than n levels
      will not be printed.  The range for n is zero-based.

--dwarf-start=n
      Print only DIEs beginning with the DIE numbered n.  This is
      only useful with --debug-dump=info.

      If specified, this option will suppress printing of any
      header information and all DIEs before the DIE numbered n.
      Only siblings and children of the specified DIE will be
      printed.

      This can be used in conjunction with --dwarf-depth.

-P
--process-links
      Display the contents of non-debug sections found in separate
      debuginfo files that are linked to the main file.  This
      option automatically implies the -wK option, and only
      sections requested by other command line options will be
      displayed.

--ctf[=section]
      Display the contents of the specified CTF section.  CTF
      sections themselves contain many subsections, all of which
      are displayed in order.

      By default, display the name of the section named .ctf, which
      is the name emitted by ld.

--ctf-parent=member
      If the CTF section contains ambiguously-defined types, it
      will consist of an archive of many CTF dictionaries, all
      inheriting from one dictionary containing unambiguous types.
      This member is by default named .ctf, like the section
      containing it, but it is possible to change this name using
      the "ctf_link_set_memb_name_changer" function at link time.
      When looking at CTF archives that have been created by a
      linker that uses the name changer to rename the parent
      archive member, --ctf-parent can be used to specify the name
```

```
           used for the parent.

       --ctf-symbols=section
       --ctf-strings=section
           Specify the name of another section from which the CTF file
           can inherit strings and symbols.  By default, the ".symtab"
           and its linked string table are used.

           If either of --ctf-symbols or --ctf-strings is specified, the
           other must be specified as well.

       -I
       --histogram
           Display a histogram of bucket list lengths when displaying
           the contents of the symbol tables.

       -v
       --version
           Display the version number of readelf.

       -W
       --wide
           Don't break output lines to fit into 80 columns. By default
           readelf breaks section header and segment listing lines for
           64-bit ELF files, so that they fit into 80 columns. This
           option causes readelf to print each section header resp. each
           segment one a single line, which is far more readable on
           terminals wider than 80 columns.

       -T
       --silent-truncation
           Normally when readelf is displaying a symbol name, and it has
           to truncate the name to fit into an 80 column display, it
           will add a suffix of "[...]" to the name.  This command line
           option disables this behaviour, allowing 5 more characters of
           the name to be displayed and restoring the old behaviour of
           readelf (prior to release 2.35).

       -H
       --help
           Display the command-line options understood by readelf.

       @file
           Read command-line options from file.  The options read are
           inserted in place of the original @file option.  If file does
           not exist, or cannot be read, then the option will be treated
           literally, and not removed.

           Options in file are separated by whitespace.  A whitespace
           character may be included in an option by surrounding the
           entire option in either single or double quotes.  Any
           character (including a backslash) may be included by
           prefixing the character to be included with a backslash.  The
           file may itself contain additional @file options; any such
           options will be processed recursively.
SEE ALSO
       objdump(1), and the Info entries for binutils.
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binutils-2.42                 2024-06-14                    READELF(1)
```

3.8 nm: List Symbols From Object Files

```
NAME
       nm - list symbols from object files
SYNOPSIS
```

```
       nm [-A|-o|--print-file-name]
          [-a|--debug-syms]
          [-B|--format=bsd]
          [-C|--demangle[=style]]
          [-D|--dynamic]
          [-fformat|--format=format]
          [-g|--extern-only]
          [-h|--help]
          [--ifunc-chars=CHARS]
          [-j|--format=just-symbols]
          [-l|--line-numbers] [--inlines]
          [-n|-v|--numeric-sort]
          [-P|--portability]
          [-p|--no-sort]
          [-r|--reverse-sort]
          [-S|--print-size]
          [-s|--print-armap]
          [-t radix|--radix=radix]
          [-u|--undefined-only]
          [-U|--defined-only]
          [-V|--version]
          [-W|--no-weak]
          [-X 32_64]
          [--no-demangle]
          [--no-recurse-limit|--recurse-limit]]
          [--plugin name]
          [--size-sort]
          [--special-syms]
          [--synthetic]
          [--target=bfdname]
          [--unicode=method]
          [--with-symbol-versions]
          [--without-symbol-versions]
          [objfile...]
DESCRIPTION
       GNU nm lists the symbols from object files objfile....  If no
       object files are listed as arguments, nm assumes the file a.out.

       For each symbol, nm shows:

       *   The symbol value, in the radix selected by options (see
           below), or hexadecimal by default.

       *   The symbol type.  At least the following types are used;
           others are, as well, depending on the object file format.  If
           lowercase, the symbol is usually local; if uppercase, the
           symbol is global (external).  There are however a few
           lowercase symbols that are shown for special global symbols
           ("u", "v" and "w").

           "A" The symbol's␣value␣is␣absolute,␣and␣will␣not␣be␣changed
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣by␣further␣linking.

␣␣␣␣␣␣␣␣␣␣␣"B"
␣␣␣␣␣␣␣␣␣␣␣"b"␣The␣symbol␣is␣in␣the␣BSS␣data␣section.␣␣This␣section
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣typically␣contains␣zero-initialized␣or␣uninitialized
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣data,␣although␣the␣exact␣behavior␣is␣system␣dependent.

␣␣␣␣␣␣␣␣␣␣␣"C"
␣␣␣␣␣␣␣␣␣␣␣"c"␣The␣symbol␣is␣common.␣␣Common␣symbols␣are␣uninitialized
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣data.␣␣When␣linking,␣multiple␣common␣symbols␣may␣appear
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣with␣the␣same␣name.␣␣If␣the␣symbol␣is␣defined␣anywhere,
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣the␣common␣symbols␣are␣treated␣as␣undefined␣references.
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣The␣lower␣case␣c␣character␣is␣used␣when␣the␣symbol␣is␣in
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣a␣special␣section␣for␣small␣commons.

␣␣␣␣␣␣␣␣␣␣␣"D"
␣␣␣␣␣␣␣␣␣␣␣"d"␣The␣symbol␣is␣in␣the␣initialized␣data␣section.

␣␣␣␣␣␣␣␣␣␣␣"G"
␣␣␣␣␣␣␣␣␣␣␣"g"␣The␣symbol␣is␣in␣an␣initialized␣data␣section␣for␣small
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣objects.␣␣Some␣object␣file␣formats␣permit␣more␣efficient
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣access␣to␣small␣data␣objects,␣such␣as␣a␣global␣int
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣variable␣as␣opposed␣to␣a␣large␣global␣array.

␣␣␣␣␣␣␣␣␣␣␣"i"␣For␣PE␣format␣files␣this␣indicates␣that␣the␣symbol␣is␣in
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣a␣section␣specific␣to␣the␣implementation␣of␣DLLs.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣For␣ELF␣format␣files␣this␣indicates␣that␣the␣symbol␣is␣an
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣indirect␣function.␣␣This␣is␣a␣GNU␣extension␣to␣the
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣standard␣set␣of␣ELF␣symbol␣types.␣␣It␣indicates␣a␣symbol
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣which␣if␣referenced␣by␣a␣relocation␣does␣not␣evaluate␣to
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣its␣address,␣but␣instead␣must␣be␣invoked␣at␣runtime.␣␣The
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣runtime␣execution␣will␣then␣return␣the␣value␣to␣be␣used
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣in␣the␣relocation.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣Note␣-␣the␣actual␣symbols␣display␣for␣GNU␣indirect
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣symbols␣is␣controlled␣by␣the␣--ifunc-chars␣command␣line
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣option.␣␣If␣this␣option␣has␣been␣provided␣then␣the␣first
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣character␣in␣the␣string␣will␣be␣used␣for␣global␣indirect
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣function␣symbols.␣␣If␣the␣string␣contains␣a␣second
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣character␣then␣that␣will␣be␣used␣for␣local␣indirect
```

```
               function symbols.

           "I" The symbol is an indirect reference to another symbol.

           "N" The symbol is a debugging symbol.

           "n" The symbol is in a non-data, non-code, non-debug read-
               only section.

           "p" The symbol is in a stack unwind section.

           "R"
           "r" The symbol is in a read only data section.

           "S"
           "s" The symbol is in an uninitialized or zero-initialized
               data section for small objects.

           "T"
           "t" The symbol is in the text (code) section.

           "U" The symbol is undefined.

           "u" The symbol is a unique global symbol.  This is a GNU
               extension to the standard set of ELF symbol bindings.
               For such a symbol the dynamic linker will make sure that
               in the entire process there is just one symbol with this
               name and type in use.

           "V"
           "v" The symbol is a weak object.  When a weak defined symbol
               is linked with a normal defined symbol, the normal
               defined symbol is used with no error.  When a weak
               undefined symbol is linked and the symbol is not defined,
               the value of the weak symbol becomes zero with no error.
               On some systems, uppercase indicates that a default value
               has been specified.

           "W"
           "w" The symbol is a weak symbol that has not been
               specifically tagged as a weak object symbol.  When a weak
               defined symbol is linked with a normal defined symbol,
               the normal defined symbol is used with no error.  When a
               weak undefined symbol is linked and the symbol is not
               defined, the value of the symbol is determined in a
               system-specific manner without error.  On some systems,
               uppercase indicates that a default value has been
               specified.

           "-" The symbol is a stabs symbol in an a.out object file.  In
               this case, the next values printed are the stabs other
               field, the stabs desc field, and the stab type.  Stabs
               symbols are used to hold debugging information.

           "?" The symbol type is unknown, or object file format
               specific.

       *   The symbol name.  If a symbol has version information
           associated with it, then the version information is displayed
           as well.  If the versioned symbol is undefined or hidden from
           linker, the version string is displayed as a suffix to the
           symbol name, preceded by an @ character.  For example
           foo@VER_1.  If the version is the default version to be used
           when resolving unversioned references to the symbol, then it
           is displayed as a suffix preceded by two @ characters.  For
           example foo@@VER_2.
OPTIONS
       The long and short forms of options, shown here as alternatives,
       are equivalent.

       -A
       -o
       --print-file-name
           Precede each symbol by the name of the input file (or archive
           member) in which it was found, rather than identifying the
           input file once only, before all of its symbols.

       -a
       --debug-syms
           Display all symbols, even debugger-only symbols; normally
           these are not listed.

       -B  The same as --format=bsd (for compatibility with the MIPS
           nm).

       -C
       --demangle[=style]
           Decode (demangle) low-level symbol names into user-level
           names.  Besides removing any initial underscore prepended by
           the system, this makes C++ function names readable. Different
           compilers have different mangling styles. The optional
           demangling style argument can be used to choose an
           appropriate demangling style for your compiler.

       --no-demangle
           Do not demangle low-level symbol names.  This is the default.

       --recurse-limit
       --no-recurse-limit
       --recursion-limit
       --no-recursion-limit
           Enables or disables a limit on the amount of recursion
           performed whilst demangling strings.  Since the name mangling
           formats allow for an infinite level of recursion it is
           possible to create strings whose decoding will exhaust the
           amount of stack space available on the host machine,
           triggering a memory fault.  The limit tries to prevent this
           from happening by restricting recursion to 2048 levels of
           nesting.

           The default is for this limit to be enabled, but disabling it
           may be necessary in order to demangle truly complicated
           names.  Note however that if the recursion limit is disabled
           then stack exhaustion is possible and any bug reports about
           such an event will be rejected.

       -D
       --dynamic
           Display the dynamic symbols rather than the normal symbols.
           This is only meaningful for dynamic objects, such as certain
           types of shared libraries.

       -f format
       --format=format
           Use the output format format, which can be "bsd", "sysv",
           "posix" or "just-symbols".  The default is "bsd".  Only the
           first character of format is significant; it can be either
           upper or lower case.

       -g
       --extern-only
           Display only external symbols.

       -h
       --help
           Show a summary of the options to nm and exit.

       --ifunc-chars=CHARS
           When display GNU indirect function symbols nm will default to
           using the "i" character for both local indirect functions and
           global indirect functions.  The --ifunc-chars option allows
           the user to specify a string containing one or two
           characters. The first character will be used for global
           indirect function symbols and the second character, if
           present, will be used for local indirect function symbols.

       j   The same as --format=just-symbols.

       -l
       --line-numbers
           For each symbol, use debugging information to try to find a
           filename and line number.  For a defined symbol, look for the
           line number of the address of the symbol.  For an undefined
           symbol, look for the line number of a relocation entry which
           refers to the symbol.  If line number information can be
           found, print it after the other symbol information.

       --inlines
           When option -l is active, if the address belongs to a
           function that was inlined, then this option causes the source
           information for all enclosing scopes back to the first non-
           inlined function to be printed as well.  For example, if
           "main" inlines "callee1" which inlines "callee2", and address
           is from "callee2", the source information for "callee1" and
           "main" will also be printed.

       -n
       -v
       --numeric-sort
           Sort symbols numerically by their addresses, rather than
           alphabetically by their names.

       -p
       --no-sort
           Do not bother to sort the symbols in any order; print them in
           the order encountered.

       -P
       --portability
           Use the POSIX.2 standard output format instead of the default
           format.  Equivalent to -f posix.

       -r
       --reverse-sort
```

```
           Reverse the order of the sort (whether numeric or
           alphabetic); let the last come first.

       -S
       --print-size
           Print both value and size of defined symbols for the "bsd"
           output style.  This option has no effect for object formats
           that do not record symbol sizes, unless --size-sort is also
           used in which case a calculated size is displayed.

       -s
       --print-armap
           When listing symbols from archive members, include the index:
           a mapping (stored in the archive by ar or ranlib) of which
           modules contain definitions for which names.

       -t radix
       --radix=radix
           Use radix as the radix for printing the symbol values.  It
           must be d for decimal, o for octal, or x for hexadecimal.

       -u
       --undefined-only
           Display only undefined symbols (those external to each object
           file).  By default both defined and undefined symbols are
           displayed.

       -U
       --defined-only
           Display only defined symbols for each object file.  By
           default both defined and undefined symbols are displayed.

       -V
       --version
           Show the version number of nm and exit.

       -X  This option is ignored for compatibility with the AIX version
           of nm.  It takes one parameter which must be the string
           32_64.  The default mode of AIX nm corresponds to -X 32,
           which is not supported by GNU nm.

       --plugin name
           Load the plugin called name to add support for extra target
           types.  This option is only available if the toolchain has
           been built with plugin support enabled.

           If --plugin is not provided, but plugin support has been
           enabled then nm iterates over the files in
           ${libdir}/bfd-plugins in alphabetic order and the first
           plugin that claims the object in question is used.

           Please note that this plugin search directory is not the one
           used by ld's -plugin option.  In order to make nm use the
           linker plugin it must be copied into the
           ${libdir}/bfd-plugins directory.  For GCC based compilations
           the linker plugin is called liblto_plugin.so.0.0.0.  For
           Clang based compilations it is called LLVMgold.so.  The GCC
           plugin is always backwards compatible with earlier versions,
           so it is sufficient to just copy the newest one.

       --size-sort
           Sort symbols by size.  For ELF objects symbol sizes are read
           from the ELF, for other object types the symbol sizes are
           computed as the difference between the value of the symbol
           and the value of the symbol with the next higher value.  If
           the "bsd" output format is used the size of the symbol is
           printed, rather than the value, and -S must be used in order
           both size and value to be printed.

           Note - this option does not work if --undefined-only has been
           enabled as undefined symbols have no size.

       --special-syms
           Display symbols which have a target-specific special meaning.
           These symbols are usually used by the target for some special
           processing and are not normally helpful when included in the
           normal symbol lists.  For example for ARM targets this option
           would skip the mapping symbols used to mark transitions
           between ARM code, THUMB code and data.

       --synthetic
           Include synthetic symbols in the output.  These are special
           symbols created by the linker for various purposes.  They are
           not shown by default since they are not part of the binary's
           original source code.

       --unicode=[default|invalid|locale|escape|hex|highlight]
           Controls the display of UTF-8 encoded multibyte characters in
           strings.  The default (--unicode=default) is to give them no
           special treatment.  The --unicode=locale option displays the
           sequence in the current locale, which may or may not support
           them.  The options --unicode=hex and --unicode=invalid
```

```
            display them as hex byte sequences enclosed by either angle
            brackets or curly braces.

            The --unicode=escape option displays them as escape sequences
            (\uxxxx) and the --unicode=highlight option displays them as
            escape sequences highlighted in red (if supported by the
            output device).  The colouring is intended to draw attention
            to the presence of unicode sequences where they might not be
            expected.

        -W
        --no-weak
            Do not display weak symbols.

        --with-symbol-versions
        --without-symbol-versions
            Enables or disables the display of symbol version
            information.  The version string is displayed as a suffix to
            the symbol name, preceded by an @ character.  For example
            foo@VER_1.  If the version is the default version to be used
            when resolving unversioned references to the symbol then it
            is displayed as a suffix preceded by two @ characters.  For
            example foo@@VER_2.  By default, symbol version information
            is displayed.

        --target=bfdname
            Specify an object code format other than your system's
            default format.

        @file
            Read command-line options from file.  The options read are
            inserted in place of the original @file option.  If file does
            not exist, or cannot be read, then the option will be treated
            literally, and not removed.

            Options in file are separated by whitespace.  A whitespace
            character may be included in an option by surrounding the
            entire option in either single or double quotes.  Any
            character (including a backslash) may be included by
            prefixing the character to be included with a backslash.  The
            file may itself contain additional @file options; any such
            options will be processed recursively.
SEE ALSO
        ar(1), objdump(1), ranlib(1), and the Info entries for binutils.
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binutils-2.42                  2024-06-14                       NM(1)
```

3.9 strace: Trace System Calls and Signals

```
NAME
        strace - trace system calls and signals
SYNOPSIS
        strace [-ACdffhikkqqrtttTvVwxxyyYzZ] [-a column] [-b execve]
               [-e expr]... [-I n] [-o file] [-O overhead] [-p pid]...
               [-P path]... [-s strsize] [-S sortby] [-U columns]
               [-X format] [--seccomp-bpf]
               [--stack-trace-frame-limit=limit] [--syscall-limit=limit]
               [--secontext[=format]] [--tips[=format]] { -p pid | [-DDD]
               [-E var[=val]]... [-u username] command [args] }

        strace -c [-dfwzZ] [-b execve] [-e expr]... [-I n] [-O overhead]
               [-p pid]... [-P path]... [-S sortby] [-U columns]
               [--seccomp-bpf] [--syscall-limit=limit] [--tips[=format]]
               { -p pid | [-DDD] [-E var[=val]]... [-u username] command
               [args] }
```

```
       strace --tips[=format]
DESCRIPTION
       In the simplest case strace runs the specified command until it
       exits.  It intercepts and records the system calls which are
       called by a process and the signals which are received by a
       process.  The name of each system call, its arguments and its
       return value are printed on standard error or to the file
       specified with the -o option.

       strace is a useful diagnostic, instructional, and debugging tool.
       System administrators, diagnosticians and trouble-shooters will
       find it invaluable for solving problems with programs for which
       the source is not readily available since they do not need to be
       recompiled in order to trace them.  Students, hackers and the
       overly-curious will find that a great deal can be learned about a
       system and its system calls by tracing even ordinary programs.
       And programmers will find that since system calls and signals are
       events that happen at the user/kernel interface, a close
       examination of this boundary is very useful for bug isolation,
       sanity checking and attempting to capture race conditions.

       Each line in the trace contains the system call name, followed by
       its arguments in parentheses and its return value.  An example
       from stracing the command "cat␣/dev/null" is:

           open("/dev/null", O_RDONLY) = 3

       Errors (typically a return value of -1) have the errno symbol and
       error string appended.

           open("/foo/bar", O_RDONLY) = -1 ENOENT (No such file or directory)

       Signals are printed as signal symbol and decoded siginfo
       structure.  An excerpt from stracing and interrupting the command
       "sleep␣666" is:

           sigsuspend([] <unfinished ...>
           --- SIGINT {si_signo=SIGINT, si_code=SI_USER, si_pid=...} ---
           +++ killed by SIGINT +++

       If a system call is being executed and meanwhile another one is
       being called from a different thread/process then strace will try
       to preserve the order of those events and mark the ongoing call
       as being unfinished.  When the call returns it will be marked as
       resumed.

           [pid 28772] select(4, [3], NULL, NULL, NULL <unfinished ...>
           [pid 28779] clock_gettime(CLOCK_REALTIME, {tv_sec=1130322148, tv_nsec=3977000}) = 0
           [pid 28772] <... select resumed> )      = 1 (in [3])

       Interruption of a (restartable) system call by a signal delivery
       is processed differently as kernel terminates the system call and
       also arranges its immediate reexecution after the signal handler
       completes.

           read(0, 0x7ffff72cf5cf, 1)              = ? ERESTARTSYS (To be restarted)
           --- SIGALRM {si_signo=SIGALRM, si_code=SI_KERNEL} ---
           rt_sigreturn({mask=[]})                 = 0
           read(0, "", 1)                          = 0

       Arguments are printed in symbolic form with passion.  This
       example shows the shell performing ">>xyzzy" output redirection:

           open("xyzzy", O_WRONLY|O_APPEND|O_CREAT, 0666) = 3

       Here, the second and the third argument of open(2) are decoded by
       breaking down the flag argument into its three bitwise-OR
       constituents and printing the mode value in octal by tradition.
       Where the traditional or native usage differs from ANSI or POSIX,
       the latter forms are preferred.  In some cases, strace output is
       proven to be more readable than the source.

       Structure pointers are dereferenced and the members are displayed
       as appropriate.  In most cases, arguments are formatted in the
       most C-like fashion possible.  For example, the essence of the
       command "ls␣-l␣/dev/null" is captured as:

           lstat("/dev/null", {st_mode=S_IFCHR|0666, st_rdev=makedev(0x1, 0x3), ...}) = 0

       Notice how the 'struct␣stat' argument is dereferenced and how
       each member is displayed symbolically.  In particular, observe
       how the st_mode member is carefully decoded into a bitwise-OR of
       symbolic and numeric values.  Also notice in this example that
       the first argument to lstat(2) is an input to the system call and
       the second argument is an output.  Since output arguments are not
       modified if the system call fails, arguments may not always be
       dereferenced.  For example, retrying the "ls␣-l" example with a
       non-existent file produces the following line:

           lstat("/foo/bar", 0xb004) = -1 ENOENT (No such file or directory)
```

In this **case** the porch light is on but nobody is home.

Syscalls unknown to strace are printed raw, with the unknown system call number printed **in** hexadecimal form and prefixed with "syscall_":

```
syscall_0xbad(0x1, 0x2, 0x3, 0x4, 0x5, 0x6) = −1 ENOSYS (Function not implemented)
```

Character pointers are dereferenced and printed as C strings. Non−printing characters **in** strings are normally represented by ordinary C escape codes. Only the first strsize (32 by default) bytes of strings are printed; longer strings have an ellipsis appended following the closing quote. Here is a line from "ls
␣␣␣␣␣␣␣−l" where the getpwuid(3) library routine is reading the password file:

```
read(3, "root::0:0:System␣Administrator:/"..., 1024) = 422
```

While structures are annotated using curly braces, pointers to basic types and arrays are printed using square brackets with commas separating the elements. Here is an example from the **command** id(1) on a system with supplementary group ids:

```
getgroups(32, [100, 0]) = 2
```

On the other hand, bit−sets are also shown using square brackets, but **set** elements are separated only by a space. Here is the shell, preparing to execute an external **command**:

```
sigprocmask(SIG_BLOCK, [CHLD TTOU], []) = 0
```

Here, the second argument is a bit−**set** of two signals, SIGCHLD and SIGTTOU. In some cases, the bit−**set** is so full that printing out the **unset** elements is more valuable. In that **case**, the bit−**set** is prefixed by a tilde like this:

```
sigprocmask(SIG_UNBLOCK, ~[], NULL) = 0
```

Here, the second argument represents the full **set** of all signals.

OPTIONS

General

−e **expr**

A qualifying expression which modifies which events to trace or how to trace them. The format of the expression is:

```
[qualifier=][!]value[,value]...
```

where qualifier is one of trace (or t), trace−fds (or trace−fd or fd or fds), abbrev (or a), verbose (or v), raw (or x), signal (or signals or s), **read** (or reads or r), write (or writes or w), fault, inject, status, quiet (or silent or silence or q), secontext, decode−fds (or decode−fd), decode−pids (or decode−pid), or kvm, and value is a qualifier−dependent symbol or number. The default qualifier is trace. Using an exclamation mark negates the **set** of values. For example, −e open means literally −e trace=open which **in** turn means trace only the open system call. By contrast, −e trace=!open means to trace every system call except open. In addition, the special values all and none have the obvious meanings.

Note that some shells use the exclamation point **for** **history** expansion even inside quoted arguments. If so, you must escape the exclamation point with a backslash.

Startup

−E var=val
−−**env**=var=val

Run **command** with var=val **in** its list of environment variables.

−E var
−−**env**=var

Remove var from the inherited list of environment variables before passing it on to the **command**.

−p pid
−−attach=pid

Attach to the process with the process ID pid and begin tracing. The trace may be terminated at any time by a keyboard interrupt signal (CTRL−C). strace will respond by detaching itself from the traced process(es) leaving it (them) to **continue** running. Multiple −p options can be used to attach to many processes **in** addition to **command** (which is optional **if** at least one −p option is given). Multiple process IDs, separated by either comma (",''),
␣␣␣␣␣␣␣␣␣␣␣␣␣␣space␣(" "),␣tab,␣or␣newline␣character,␣can␣be␣provided␣as
␣␣␣␣␣␣␣␣␣␣␣␣␣␣an␣argument␣to␣a␣single␣−p␣option,␣so,␣for␣example,␣−p
␣␣␣␣␣␣␣␣␣␣␣␣␣␣"$(pidof PROG)"␣and␣−p␣"$(pgrep PROG)"␣syntaxes␣are
␣␣␣␣␣␣␣␣␣␣␣␣␣␣supported.

```
␣␣␣␣␣␣␣-u␣username
␣␣␣␣␣␣␣--user=username
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Run␣command␣with␣the␣user␣ID,␣group␣ID,␣and␣supplementary
␣␣␣␣␣␣␣␣␣␣␣␣␣␣groups␣of␣username.␣␣This␣option␣is␣only␣useful␣when
␣␣␣␣␣␣␣␣␣␣␣␣␣␣running␣as␣root␣and␣enables␣the␣correct␣execution␣of
␣␣␣␣␣␣␣␣␣␣␣␣␣␣setuid␣and/or␣setgid␣binaries.␣␣Unless␣this␣option␣is␣used
␣␣␣␣␣␣␣␣␣␣␣␣␣␣setuid␣and␣setgid␣programs␣are␣executed␣without␣effective
␣␣␣␣␣␣␣␣␣␣␣␣␣␣privileges.
␣␣␣␣␣␣␣-u␣UID:GID
␣␣␣␣␣␣␣--user=UID:GID
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Alternative␣syntax␣where␣the␣program␣is␣started␣with
␣␣␣␣␣␣␣␣␣␣␣␣␣␣exactly␣the␣given␣user␣and␣group␣IDs,␣and␣an␣empty␣list␣of
␣␣␣␣␣␣␣␣␣␣␣␣␣␣supplementary␣groups.␣␣In␣this␣case,␣user␣and␣group␣name
␣␣␣␣␣␣␣␣␣␣␣␣␣␣lookups␣are␣not␣performed.

␣␣␣␣␣␣␣--argv0=name
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Set␣argv[0]␣of␣the␣command␣being␣executed␣to␣name.␣␣Useful
␣␣␣␣␣␣␣␣␣␣␣␣␣␣for␣tracing␣multi-call␣executables␣which␣interpret
␣␣␣␣␣␣␣␣␣␣␣␣␣␣argv[0],␣such␣as␣busybox␣or␣kmod.

␣␣␣Tracing
␣␣␣␣␣␣␣-b␣syscall
␣␣␣␣␣␣␣--detach-on=syscall
␣␣␣␣␣␣␣␣␣␣␣␣␣␣If␣specified␣syscall␣is␣reached,␣detach␣from␣traced
␣␣␣␣␣␣␣␣␣␣␣␣␣␣process.␣␣Currently,␣only␣execve(2)␣syscall␣is␣supported.
␣␣␣␣␣␣␣␣␣␣␣␣␣␣This␣option␣is␣useful␣if␣you␣want␣to␣trace␣multi-threaded
␣␣␣␣␣␣␣␣␣␣␣␣␣␣process␣and␣therefore␣require␣-f,␣but␣don't␣want␣to␣trace
␣␣␣␣␣␣␣␣␣␣␣␣␣␣its␣(potentially␣very␣complex)␣children.

␣␣␣␣␣␣␣-D
␣␣␣␣␣␣␣--daemonize
␣␣␣␣␣␣␣--daemonize=grandchild
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Run␣tracer␣process␣as␣a␣grandchild,␣not␣as␣the␣parent␣of
␣␣␣␣␣␣␣␣␣␣␣␣␣␣the␣tracee.␣␣This␣reduces␣the␣visible␣effect␣of␣strace␣by
␣␣␣␣␣␣␣␣␣␣␣␣␣␣keeping␣the␣tracee␣a␣direct␣child␣of␣the␣calling␣process.

␣␣␣␣␣␣␣-DD
␣␣␣␣␣␣␣--daemonize=pgroup
␣␣␣␣␣␣␣--daemonize=pgrp
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Run␣tracer␣process␣as␣tracee's␣grandchild␣in␣a␣separate
␣␣␣␣␣␣␣␣␣␣␣␣␣␣process␣group.␣␣In␣addition␣to␣reduction␣of␣the␣visible
␣␣␣␣␣␣␣␣␣␣␣␣␣␣effect␣of␣strace,␣it␣also␣avoids␣killing␣of␣strace␣with
␣␣␣␣␣␣␣␣␣␣␣␣␣␣kill(2)␣issued␣to␣the␣whole␣process␣group.

␣␣␣␣␣␣␣-DDD
␣␣␣␣␣␣␣--daemonize=session
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Run␣tracer␣process␣as␣tracee's␣grandchild␣in␣a␣separate
␣␣␣␣␣␣␣␣␣␣␣␣␣␣session␣("true daemonisation").␣␣In␣addition␣to␣reduction
␣␣␣␣␣␣␣␣␣␣␣␣␣␣of␣the␣visible␣effect␣of␣strace,␣it␣also␣avoids␣killing␣of
␣␣␣␣␣␣␣␣␣␣␣␣␣␣strace␣upon␣session␣termination.

␣␣␣␣␣␣␣-f
␣␣␣␣␣␣␣--follow-forks
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Trace␣child␣processes␣as␣they␣are␣created␣by␣currently
␣␣␣␣␣␣␣␣␣␣␣␣␣␣traced␣processes␣as␣a␣result␣of␣the␣fork(2),␣vfork(2)␣and
␣␣␣␣␣␣␣␣␣␣␣␣␣␣clone(2)␣system␣calls.␣␣Note␣that␣-p␣PID␣-f␣will␣attach
␣␣␣␣␣␣␣␣␣␣␣␣␣␣all␣threads␣of␣process␣PID␣if␣it␣is␣multi-threaded,␣not
␣␣␣␣␣␣␣␣␣␣␣␣␣␣only␣thread␣with␣thread_id␣=␣PID.

␣␣␣␣␣␣␣--output-separately
␣␣␣␣␣␣␣␣␣␣␣␣␣␣If␣the␣--output=filename␣option␣is␣in␣effect,␣each
␣␣␣␣␣␣␣␣␣␣␣␣␣␣processes␣trace␣is␣written␣to␣filename.pid␣where␣pid␣is
␣␣␣␣␣␣␣␣␣␣␣␣␣␣the␣numeric␣process␣id␣of␣each␣process.

␣␣␣␣␣␣␣-ff
␣␣␣␣␣␣␣--follow-forks␣--output-separately
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Combine␣the␣effects␣of␣--follow-forks␣and
␣␣␣␣␣␣␣␣␣␣␣␣␣␣--output-separately␣options.␣␣This␣is␣incompatible␣with
␣␣␣␣␣␣␣␣␣␣␣␣␣␣-c,␣since␣no␣per-process␣counts␣are␣kept.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣One␣might␣want␣to␣consider␣using␣strace-log-merge(1)␣to
␣␣␣␣␣␣␣␣␣␣␣␣␣␣obtain␣a␣combined␣strace␣log␣view.

␣␣␣␣␣␣␣-I␣interruptible
␣␣␣␣␣␣␣--interruptible=interruptible
␣␣␣␣␣␣␣␣␣␣␣␣␣␣When␣strace␣can␣be␣interrupted␣by␣signals␣(such␣as
␣␣␣␣␣␣␣␣␣␣␣␣␣␣pressing␣CTRL-C).

␣␣␣␣␣␣␣␣␣␣␣␣␣␣1,␣anywhere
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣no␣signals␣are␣blocked;
␣␣␣␣␣␣␣␣␣␣␣␣␣␣2,␣waiting
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣fatal␣signals␣are␣blocked␣while␣decoding␣syscall
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣(default);
␣␣␣␣␣␣␣␣␣␣␣␣␣␣3,␣never
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣fatal␣signals␣are␣always␣blocked␣(default␣if␣-o
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣FILE␣PROG);
␣␣␣␣␣␣␣␣␣␣␣␣␣␣4,␣never_tstp
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣fatal␣signals␣and␣SIGTSTP␣(CTRL-Z)␣are␣always
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣blocked␣(useful␣to␣make␣strace␣-o␣FILE␣PROG␣not
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣stop␣on␣CTRL-Z,␣default␣if␣-D).

␣␣␣␣␣␣␣--syscall-limit=limit
```

```
              Detach all tracees when limit number of syscalls have been
              captured. Syscalls filtered out via --trace, --trace-path
              or --status options are not considered when keeping track
              of the number of syscalls that are captured.

       --kill-on-exit
              Apply PTRACE_O_EXITKILL ptrace option to all tracee
              processes (which sends a SIGKILL signal to the tracee if
              the tracer exits) and do not detach them on cleanup so
              they will not be left running after the tracer exit.
              --kill-on-exit is not compatible with -p/--attach options.

   Filtering
       -e trace=syscall_set
       -e t=syscall_set
       --trace=syscall_set
              Trace only the specified set of system calls.  syscall_set
              is defined as [!]value[,value], and value can be one of
              the following:

              syscall
                     Trace specific syscall, specified by its name (see
                     syscalls(2) for a reference, but also see NOTES).

              ?value Question mark before the syscall qualification
                     allows suppression of error in case no syscalls
                     matched the qualification provided.

              value@64
                     Limit the syscall specification described by value
                     to 64-bit personality.

              value@32
                     Limit the syscall specification described by value
                     to 32-bit personality.

              value@x32
                     Limit the syscall specification described by value
                     to x32 personality.

              all    Trace all system calls.

              /regex Trace only those system calls that match the regex.
                     You can use POSIX Extended Regular Expression
                     syntax (see regex(7)).

              %file
              file   Trace all system calls which take a file name as an
                     argument.  You can think of this as an abbreviation
                     for -e trace=open,stat,chmod,unlink,...  which is
                     useful to seeing what files the process is
                     referencing.  Furthermore, using the abbreviation
                     will ensure that you don't accidentally forget to
                     include a call like lstat(2) in the list.  Betchya
                     woulda forgot that one.  The syntax without a
                     preceding percent sign ("-e trace=file") is
                     deprecated.

              %process
              process
                     Trace system calls associated with process
                     lifecycle (creation, exec, termination).  The
                     syntax without a preceding percent sign ("-e
                     trace=process") is deprecated.

              %net
              %network
              network
                     Trace all the network related system calls.  The
                     syntax without a preceding percent sign ("-e
                     trace=network") is deprecated.

              %signal
              signal Trace all signal related system calls.  The syntax
                     without a preceding percent sign ("-e
                     trace=signal") is deprecated.

              %ipc
              ipc    Trace all IPC related system calls.  The syntax
                     without a preceding percent sign ("-e trace=ipc")
                     is deprecated.

              %desc
              desc   Trace all file descriptor related system calls.
                     The syntax without a preceding percent sign ("-e
                     trace=desc") is deprecated.

              %memory
              memory Trace all memory mapping related system calls.  The
                     syntax without a preceding percent sign ("-e
                     trace=memory") is deprecated.
              %creds Trace system calls that read or modify user and
                     group identifiers or capability sets.

              %stat  Trace stat syscall variants.

              %lstat Trace lstat syscall variants.

              %fstat Trace fstat, fstatat, and statx syscall variants.

              %%stat Trace syscalls used for requesting file status
                     (stat, lstat, fstat, fstatat, statx, and their
                     variants).

              %statfs
                     Trace statfs, statfs64, statvfs, osf_statfs, and
                     osf_statfs64 system calls.  The same effect can be
                     achieved with -e trace=/^(.*_)?statv?fs regular
                     expression.

              %fstatfs
                     Trace fstatfs, fstatfs64, fstatvfs, osf_fstatfs,
                     and osf_fstatfs64 system calls.  The same effect
                     can be achieved with -e trace=/fstatv?fs regular
                     expression.

              %%statfs
                     Trace syscalls related to file system statistics
                     (statfs-like, fstatfs-like, and ustat).  The same
                     effect can be achieved with
                     -e trace=/statv?fs|fsstat|ustat regular expression.

              %clock Trace system calls that read or modify system
                     clocks.

              %pure  Trace syscalls that always succeed and have no
                     arguments.  Currently, this list includes
                     arc_gettls(2), getdtablesize(2), getegid(2),
                     getegid32(2), geteuid(2), geteuid32(2), getgid(2),
                     getgid32(2), getpagesize(2), getpgrp(2), getpid(2),
                     getppid(2), get_thread_area(2) (on architectures
                     other than x86), gettid(2), get_tls(2), getuid(2),
                     getuid32(2), getxgid(2), getxpid(2), getxuid(2),
                     kern_features(2), and metag_get_tls(2) syscalls.

              The -c option is useful for determining which system calls
              might be useful to trace.  For example,
              trace=open,close,read,write means to only trace those four
              system calls.  Be careful when making inferences about the
              user/kernel boundary if only a subset of system calls are
              being monitored.  The default is trace=all.

       -e trace-fd=set
       -e trace-fds=set
       -e fd=set
       -e fds=set
       --trace-fds=set
              Trace only the syscalls that operate on the specified
              subset of (non-negative) file descriptors.  Note that
              usage of this option also filters out all the syscalls
              that do not operate on file descriptors at all.  Applies
              in (inclusive) disjunction with the --trace-path option.

       -e signal=set
       -e signals=set
       -e s=set
       --signal=set
              Trace only the specified subset of signals.  The default
              is signal=all.  For example, signal=!SIGIO (or signal=!io)
              causes SIGIO signals not to be traced.

       -e status=set
       --status=set
              Print only system calls with the specified return status.
              The default is status=all.  When using the status
              qualifier, because strace waits for system calls to return
              before deciding whether they should be printed or not, the
              traditional order of events may not be preserved anymore.
              If two system calls are executed by concurrent threads,
              strace will first print both the entry and exit of the
              first system call to exit, regardless of their respective
              entry time.  The entry and exit of the second system call
              to exit will be printed afterwards.  Here is an example
              when select(2) is called, but a different thread calls
              clock_gettime(2) before select(2) finishes:

                  [pid 28779] 1130322148.939977 clock_gettime(CLOCK_REALTIME, {1130322148, 939977000}) = 0
                  [pid 28772] 1130322148.438139 select(4, [3], NULL, NULL, NULL) = 1 (in [3])

              set can include the following elements:

              successful
                     Trace system calls that returned without an error
                     code.  The -z option has the effect of
                     status=successful.
              failed Trace system calls that returned with an error
                     code.  The -Z option has the effect of
                     status=failed.
              unfinished
                     Trace system calls that did not return.  This might
                     happen, for example, due to an execve call in a
                     neighbour thread.
              unavailable
                     Trace system calls that returned but strace failed
                     to fetch the error status.
              detached
                     Trace system calls for which strace detached before
                     the return.

       -P path
       --trace-path=path
              Trace only system calls accessing path.  Multiple -P
              options can be used to specify several paths.  Applies in
              (inclusive) disjunction with the --trace-fds option.

       -z
       --successful-only
              Print only syscalls that returned without an error code.

       -Z
       --failed-only
              Print only syscalls that returned with an error code.

   Output format
       -a column
       --columns=column
              Align return values in a specific column (default column
              40).

       -e abbrev=syscall set
       -e a=syscall set
       --abbrev=syscall set
              Abbreviate the output from printing each member of large
              structures.  The syntax of the syscall set specification
              is the same as in the -e trace option.  The default is
              abbrev=all.  The -v option has the effect of abbrev=none.

       -e verbose=syscall set
       -e v=syscall set
       --verbose=syscall set
              Dereference structures for the specified set of system
              calls.  The syntax of the syscall set specification is the
              same as in the -e trace option.  The default is
              verbose=all.

       -e raw=syscall set
       -e x=syscall set
       --raw=syscall set
              Print raw, undecoded arguments for the specified set of
              system calls.  The syntax of the syscall set specification
              is the same as in the -e trace option.  This option has
              the effect of causing all arguments to be printed in
              hexadecimal.  This is mostly useful if you don't trust the
              decoding or you need to know the actual numeric value of
              an argument.  See also -X raw option.

       -e read=set
       -e reads=set
       -e r=set
       --read=set
              Perform a full hexadecimal and ASCII dump of all the data
              read from file descriptors listed in the specified set.
              For example, to see all input activity on file descriptors
              3 and 5 use -e read=3,5.  Note that this is independent
              from the normal tracing of the read(2) system call which
              is controlled by the option -e trace=read.

       -e write=set
       -e writes=set
       -e w=set
       --write=set
              Perform a full hexadecimal and ASCII dump of all the data
              written to file descriptors listed in the specified set.
              For example, to see all output activity on file
              descriptors 3 and 5 use -e write=3,5.  Note that this is
              independent from the normal tracing of the write(2) system
              call which is controlled by the option -e trace=write.

       -e quiet=set
       -e silent=set
       -e silence=set
       -e q=set
       --quiet=set
       --silent=set
       --silence=set
```

```
              Suppress various information messages.  The default is
              quiet=none.  set can include the following elements:

              attach Suppress messages about attaching and detaching ("[
                     Process NNNN attached ]", "[ Process NNNN detached
                     ]").
              exit   Suppress messages about process exits ("+++ exited
                     with SSS +++").
              path-resolution
                     Suppress messages about resolution of paths
                     provided via the -P option ("Requested path "..."
                     resolved into "..."").
              personality
                     Suppress messages about process personality changes
                     ("[ Process PID=NNNN runs in PPP mode. ]").
              thread-execve
              superseded
                     Suppress messages about process being superseded by
                     execve(2) in another thread ("+++ superseded by
                     execve in pid NNNN +++").

       -e decode-fds=set
       --decode-fds=set
              Decode various information associated with file
              descriptors.  The default is decode-fds=none.  set can
              include the following elements:

              path     Print file paths.  Also enables printing of
                       tracee's current working directory when AT_FDCWD
                       constant is used.
              socket   Print socket protocol-specific information,
              dev      Print character/block device numbers.
              pidfd    Print PIDs associated with pidfd file
                       descriptors.
              signalfd Print signal masks associated with signalfd file
                       descriptors.

       -e decode-pids=set
       --decode-pids=set
              Decode various information associated with process IDs
              (and also thread IDs, process group IDs, and session IDs).
              The default is decode-pids=none.  set can include the
              following elements:

              comm   Print command names associated with thread or
                     process IDs.
              pidns  Print thread, process, process group, and session
                     IDs in strace's PID namespace if the tracee is in
                     a different PID namespace.

       -e kvm=vcpu
       --kvm=vcpu
              Print the exit reason of kvm vcpu.  Requires Linux kernel
              version 4.16.0 or higher.

       -i
       --instruction-pointer
              Print the instruction pointer at the time of the system
              call.

       -n
       --syscall-number
              Print the syscall number.

       -k
       --stack-trace[=symbol]
              Print the execution stack trace of the traced processes
              after each system call.

       -kk
       --stack-trace=source
              Print the execution stack trace and source code
              information of the traced processes after each system
              call. This option expects the target program is compiled
              with appropriate debug options: "-g" (gcc), or "-g
             -gdwarf-aranges" (clang).

       --stack-trace-frame-limit=limit
              Print no more than this amount of stack trace frames when
              backtracing a system call (the default is 256).  Use this
              option with the --stack-trace (or -k) option.

       -o filename
       --output=filename
              Write the trace output to the file filename rather than to
              stderr.  filename.pid form is used if -ff option is
              supplied.  If the argument begins with '|' or '!', the
              rest of the argument is treated as a command and all
              output is piped to it.  This is convenient for piping the
              debugging output to a program without affecting the
              redirections of executed programs.  The latter is not
              compatible with -ff option currently.
       -A
       --output-append-mode
              Open the file provided in the -o option in append mode.

       -q
       --quiet
       --quiet=attach,personality
              Suppress messages about attaching, detaching, and
              personality changes.  This happens automatically when
              output is redirected to a file and the command is run
              directly instead of attaching.

       -qq
       --quiet=attach,personality,exit
              Suppress messages attaching, detaching, personality
              changes, and about process exit status.

       -qqq
       --quiet=all
              Suppress all suppressible messages (please refer to the -e
              quiet option description for the full list of suppressible
              messages).

       -r
       --relative-timestamps[=precision]
              Print a relative timestamp upon entry to each system call.
              This records the time difference between the beginning of
              successive system calls.  precision can be one of s (for
              seconds), ms (milliseconds), us (microseconds), or ns
              (nanoseconds), and allows setting the precision of time
              value being printed.  Default is us (microseconds).  Note
              that since -r option uses the monotonic clock time for
              measuring time difference and not the wall clock time, its
              measurements can differ from the difference in time
              reported by the -t option.

       -s strsize
       --string-limit=strsize
              Specify the maximum string size to print (the default is
              32).  Note that filenames are not considered strings and
              are always printed in full.

       --absolute-timestamps[=[[format:]format],[[precision:]precision]]
       --timestamps[=[[format:]format],[[precision:]precision]]
              Prefix each line of the trace with the wall clock time in
              the specified format with the specified precision.  format
              can be one of the following:

              none   No time stamp is printed.  Can be used to override
                     the previous setting.
              time   Wall clock time (strftime(3) format string is %T).
              unix   Number of seconds since the epoch (strftime(3)
                     format string is %s).

              precision can be one of s (for seconds), ms
              (milliseconds), us (microseconds), or ns (nanoseconds).
              Default arguments for the option are
              format:time,precision:s.

       -t
       --absolute-timestamps
              Prefix each line of the trace with the wall clock time.

       -tt
       --absolute-timestamps=precision:us
              If given twice, the time printed will include the
              microseconds.

       -ttt
       --absolute-timestamps=format:unix,precision:us
              If given thrice, the time printed will include the
              microseconds and the leading portion will be printed as
              the number of seconds since the epoch.

       -T
       --syscall-times[=precision]
              Show the time spent in system calls.  This records the
              time difference between the beginning and the end of each
              system call.  precision can be one of s (for seconds), ms
              (milliseconds), us (microseconds), or ns (nanoseconds),
              and allows setting the precision of time value being
              printed.  Default is us (microseconds).

       -v
       --no-abbrev
              Print unabbreviated versions of environment, stat,
              termios, etc.  calls.  These structures are very common in
              calls and so the default behavior displays a reasonable
              subset of structure members.  Use this option to get all
              of the gory details.
```

```
␣␣␣␣␣␣␣--strings-in-hex[=option]
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Control␣usage␣of␣escape␣sequences␣with␣hexadecimal␣numbers
␣␣␣␣␣␣␣␣␣␣␣␣␣␣in␣the␣printed␣strings.␣␣Normally␣(when␣no
␣␣␣␣␣␣␣␣␣␣␣␣␣␣--strings-in-hex␣or␣-x␣option␣is␣supplied),␣escape
␣␣␣␣␣␣␣␣␣␣␣␣␣␣sequences␣are␣used␣to␣print␣non-printable␣and␣non-ASCII
␣␣␣␣␣␣␣␣␣␣␣␣␣␣characters␣(that␣is,␣characters␣with␣a␣character␣code␣less
␣␣␣␣␣␣␣␣␣␣␣␣␣␣than␣32␣or␣greater␣than␣127),␣or␣to␣disambiguate␣the
␣␣␣␣␣␣␣␣␣␣␣␣␣␣output␣(so,␣for␣quotes␣and␣other␣characters␣that␣encase
␣␣␣␣␣␣␣␣␣␣␣␣␣␣the␣printed␣string,␣for␣example,␣angle␣brackets,␣in␣case
␣␣␣␣␣␣␣␣␣␣␣␣␣␣of␣file␣descriptor␣path␣output);␣for␣the␣former␣use␣case,
␣␣␣␣␣␣␣␣␣␣␣␣␣␣unless␣it␣is␣a␣white␣space␣character␣that␣has␣a␣symbolic
␣␣␣␣␣␣␣␣␣␣␣␣␣␣escape␣sequence␣defined␣in␣the␣C␣standard␣(that␣is,␣"\textbackslash t"
␣␣␣␣␣␣␣␣␣␣␣␣␣␣for␣a␣horizontal␣tab,␣"\textbackslash n"␣for␣a␣newline,␣"\textbackslash v"␣for␣a
␣␣␣␣␣␣␣␣␣␣␣␣␣␣vertical␣tab,␣"\textbackslash f"␣for␣a␣form␣feed␣page␣break,␣and␣"\textbackslash r"
␣␣␣␣␣␣␣␣␣␣␣␣␣␣for␣a␣carriage␣return)␣are␣printed␣using␣escape␣sequences
␣␣␣␣␣␣␣␣␣␣␣␣␣␣with␣numbers␣that␣correspond␣to␣their␣byte␣values,␣with
␣␣␣␣␣␣␣␣␣␣␣␣␣␣octal␣number␣format␣being␣the␣default.␣␣option␣can␣be␣one
␣␣␣␣␣␣␣␣␣␣␣␣␣␣of␣the␣following:

␣␣␣␣␣␣␣␣␣␣␣␣␣␣none␣␣␣Hexadecimal␣numbers␣are␣not␣used␣in␣the␣output␣at
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣all.␣␣When␣there␣is␣a␣need␣to␣emit␣an␣escape
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣sequence,␣octal␣numbers␣are␣used.
␣␣␣␣␣␣␣␣␣␣␣␣␣␣non-ascii-chars
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣Hexadecimal␣numbers␣are␣used␣instead␣of␣octal␣in
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣the␣escape␣sequences.
␣␣␣␣␣␣␣␣␣␣␣␣␣␣non-ascii
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣Strings␣that␣contain␣non-ASCII␣characters␣are
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣printed␣using␣escape␣sequences␣with␣hexadecimal
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣numbers.
␣␣␣␣␣␣␣␣␣␣␣␣␣␣all␣␣␣␣All␣strings␣are␣printed␣using␣escape␣sequences␣with
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣hexadecimal␣numbers.

␣␣␣␣␣␣␣␣␣␣␣␣␣␣When␣the␣option␣is␣supplied␣without␣an␣argument,␣all␣is
␣␣␣␣␣␣␣␣␣␣␣␣␣␣assumed.

␣␣␣␣␣␣␣-x
␣␣␣␣␣␣␣--strings-in-hex=non-ascii
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Print␣all␣non-ASCII␣strings␣in␣hexadecimal␣string␣format.

␣␣␣␣␣␣␣-xx
␣␣␣␣␣␣␣--strings-in-hex[=all]
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Print␣all␣strings␣in␣hexadecimal␣string␣format.

␣␣␣␣␣␣␣-X␣format
␣␣␣␣␣␣␣--const-print-style=format
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Set␣the␣format␣for␣printing␣of␣named␣constants␣and␣flags.
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Supported␣format␣values␣are:

␣␣␣␣␣␣␣␣␣␣␣␣␣␣raw␣␣␣␣Raw␣number␣output,␣without␣decoding.
␣␣␣␣␣␣␣␣␣␣␣␣␣␣abbrev␣Output␣a␣named␣constant␣or␣a␣set␣of␣flags␣instead
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣of␣the␣raw␣number␣if␣they␣are␣found.␣␣This␣is␣the
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣default␣strace␣behaviour.
␣␣␣␣␣␣␣␣␣␣␣␣␣␣verbose
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣Output␣both␣the␣raw␣value␣and␣the␣decoded␣string
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣(as␣a␣comment).

␣␣␣␣␣␣␣-y
␣␣␣␣␣␣␣--decode-fds
␣␣␣␣␣␣␣--decode-fds=path
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Print␣paths␣associated␣with␣file␣descriptor␣arguments␣and
␣␣␣␣␣␣␣␣␣␣␣␣␣␣with␣the␣AT_FDCWD␣constant.

␣␣␣␣␣␣␣-yy
␣␣␣␣␣␣␣--decode-fds=all
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Print␣all␣available␣information␣associated␣with␣file
␣␣␣␣␣␣␣␣␣␣␣␣␣␣descriptors:␣protocol-specific␣information␣associated␣with
␣␣␣␣␣␣␣␣␣␣␣␣␣␣socket␣file␣descriptors,␣block/character␣device␣number
␣␣␣␣␣␣␣␣␣␣␣␣␣␣associated␣with␣device␣file␣descriptors,␣and␣PIDs
␣␣␣␣␣␣␣␣␣␣␣␣␣␣associated␣with␣pidfd␣file␣descriptors.

␣␣␣␣␣␣␣--pidns-translation
␣␣␣␣␣␣␣--decode-pids=pidns
␣␣␣␣␣␣␣␣␣␣␣␣␣␣If␣strace␣and␣tracee␣are␣in␣different␣PID␣namespaces,
␣␣␣␣␣␣␣␣␣␣␣␣␣␣print␣PIDs␣in␣strace's␣namespace,␣too.

␣␣␣␣␣␣␣-Y
␣␣␣␣␣␣␣--decode-pids=comm
␣␣␣␣␣␣␣␣␣␣␣␣␣␣Print␣command␣names␣for␣PIDs.

␣␣␣␣␣␣␣--secontext[=format]
␣␣␣␣␣␣␣-e␣secontext=format
␣␣␣␣␣␣␣␣␣␣␣␣␣␣When␣SELinux␣is␣available␣and␣is␣not␣disabled,␣print␣in
␣␣␣␣␣␣␣␣␣␣␣␣␣␣square␣brackets␣SELinux␣contexts␣of␣processes,␣files,␣and
␣␣␣␣␣␣␣␣␣␣␣␣␣␣descriptors.␣␣The␣format␣argument␣is␣a␣comma-separated
␣␣␣␣␣␣␣␣␣␣␣␣␣␣list␣of␣items␣being␣one␣of␣the␣following:

␣␣␣␣␣␣␣␣␣␣␣␣␣␣full␣␣␣␣␣␣␣␣␣␣␣␣␣␣Print␣the␣full␣context␣(user,␣role,␣type
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣level␣and␣category).
␣␣␣␣␣␣␣␣␣␣␣␣␣␣mismatch␣␣␣␣␣␣␣␣␣␣Also␣print␣the␣context␣recorded␣by␣the
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣SELinux␣database␣in␣case␣the␣current
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣context␣differs.␣␣The␣latter␣is␣printed
␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣after␣two␣exclamation␣marks␣(!!).
```

```
              The default value for --secontext is !full,mismatch which
              prints only the type instead of full context and doesn't
              check for context mismatches.

       --always-show-pid
              Show PID prefix also for the process started by strace.
              Implied when -f and -o are both specified.

   Statistics
       -c
       --summary-only
              Count time, calls, and errors for each system call and
              report a summary on program exit, suppressing the regular
              output.  This attempts to show system time (CPU time spent
              running in the kernel) independent of wall clock time.  If
              -c is used with -f, only aggregate totals for all traced
              processes are kept.

       -C
       --summary
              Like -c but also print regular output while processes are
              running.

       -O overhead
       --summary-syscall-overhead=overhead
              Set the overhead for tracing system calls to overhead.
              This is useful for overriding the default heuristic for
              guessing how much time is spent in mere measuring when
              timing system calls using the -c option.  The accuracy of
              the heuristic can be gauged by timing a given program run
              without tracing (using time(1)) and comparing the
              accumulated system call time to the total produced using
              -c.

              The format of overhead specification is described in
              section Time specification format description.

       -S sortby
       --summary-sort-by=sortby
              Sort the output of the histogram printed by the -c option
              by the specified criterion.  Legal values are time (or
              time-percent or time-total or total-time), min-time (or
              shortest or time-min), max-time (or longest or time-max),
              avg-time (or time-avg), calls (or count), errors (or
              error), name (or syscall or syscall-name), and nothing (or
              none); default is time.

       -U columns
       --summary-columns=columns
              Configure a set (and order) of columns being shown in the
              call summary.  The columns argument is a comma-separated
              list with items being one of the following:

              time-percent (or time)
                     Percentage of cumulative time consumed by a
                     specific system call.
              total-time (or time-total)
                     Total system (or wall clock, if -w option is
                     provided) time consumed by a specific system call.
              min-time (or shortest or time-min)
                     Minimum observed call duration.
              max-time (or longest or time-max)
                     Maximum observed call duration.
              avg-time (or time-avg)
                     Average call duration.
              calls (or count)
                     Call count.
              errors (or error)
                     Error count.
              name (or syscall or syscall-name)
                     Syscall name.

              The default value is
              time-percent,total-time,avg-time,calls,errors,name.  If
              the name field is not supplied explicitly, it is added as
              the last column.

       -w
       --summary-wall-clock
              Summarise the time difference between the beginning and
              end of each system call.  The default is to summarise the
              system time.

   Tampering
       -e inject=syscall_set[:error=errno|:retval=value][:signal=sig]
       [:syscall=syscall][:delay_enter=delay][:delay_exit=delay]
       [:poke_enter=@argN=DATAN,@argM=DATAM...]
       [:poke_exit=@argN=DATAN,@argM=DATAM...][:when=expr]
       --inject=syscall_set[:error=errno|:retval=value][:signal=sig]
       [:syscall=syscall][:delay_enter=delay][:delay_exit=delay]
       [:poke_enter=@argN=DATAN,@argM=DATAM...]
       [:poke_exit=@argN=DATAN,@argM=DATAM...] [:when=expr]
              Perform  syscall  tampering  for  the  specified  set  of
              syscalls.  The syntax of the syscall set specification  is
              the same as in the -e trace option.

              At  least  one  of  error,  retval,  signal,  delay_enter,
              delay_exit, poke_enter, or poke_exit  options  has  to  be
              specified.  error and retval are mutually exclusive.

              If  :error=errno  option is specified, a fault is injected
              into a syscall invocation: the syscall number is  replaced
              by  -1  which  corresponds to an invalid syscall (unless a
              syscall is specified with :syscall= option), and the error
              code is specified using a symbolic errno value like ENOSYS
              or a numeric value within 1..4095 range.

              If :retval=value option is specified, success injection is
              performed: the syscall number is replaced  by  -1,  but  a
              bogus success value is returned to the callee.

              If  :signal=sig option is specified with either a symbolic
              value like SIGSEGV or a numeric value  within  1..SIGRTMAX
              range,  that signal is delivered on entering every syscall
              specified by the set.

              If :delay_enter=delay  or  :delay_exit=delay  options  are
              specified,  delay  injection  is  performed: the tracee is
              delayed by time period specified by delay on  entering  or
              exiting  the  syscall,  respectively.  The format of delay
              specification is described in section  Time  specification
              format description.

              If        :poke_enter=@argN=DATAN,@argM=DATAM...        or
              :poke_exit=@argN=DATAN,@argM=DATAM...     options      are
              specified,  tracee's  memory  at  locations, pointed to by
              system call arguments argN and argM (going  from  arg1  to
              arg7) is overwritten by data DATAN and DATAM (specified in
              hexadecimal          format;          for          example
              :poke_enter=@arg1=0000DEAD0000BEEF).  :poke_enter modifies
              memory on syscall enter, and :poke_exit - on exit.

              If :signal=sig option is specified  without  :error=errno,
              :retval=value  or  :delay_{enter,exit}=usecs options, then
              only a signal sig is delivered without a syscall fault  or
              delay     injection.     Conversely,    :error=errno    or
              :retval=value    option    without    :delay_enter=delay,
              :delay_exit=delay  or  :signal=sig options injects a fault
              without delivering a signal or injecting a delay, etc.

              If  :signal=sig  option   is   specified   together   with
              :error=errno  or  :retval=value,  then both injection of a
              fault or success and signal delivery are performed.

              if :syscall=syscall option is specified, the corresponding
              syscall with no side effects is injected  instead  of  -1.
              Currently,  only  "pure"  (see -e trace=%pure description)
              syscalls can be specified there.

              Unless  a  :when=expr  subexpression  is   specified,   an
              injection  is  being  made  into  every invocation of each
              syscall from the set.

              The format of the subexpression is:

                            first[..last][+[step]]

              Number first stands for the first invocation number in the
              range, number last stands for the last  invocation  number
              in  the  range,  and  step stands for the step between two
              consecutive invocations.  The following  combinations  are
              useful:

              first  For every syscall from the set, perform an
                     injection for the syscall invocation number first
                     only.
              first..last
                     For every syscall from the set, perform an
                     injection for the syscall invocation number first
                     and all subsequent invocations until the invocation
                     number last (inclusive).
              first+ For every syscall from the set, perform injections
                     for the syscall invocation number first and all
                     subsequent invocations.
              first..last+
                     For every syscall from the set, perform injections
                     for the syscall invocation number first and all
                     subsequent invocations until the invocation number
                     last (inclusive).
              first+step
                     For every syscall from the set, perform injections
                     for syscall invocations number first, first+step,
                     first+step+step, and so on.
              first..last+step
                     Same as the previous, but consider only syscall
                     invocations with numbers up to last (inclusive).

              For example, to fail each third and subsequent chdir
              syscalls with ENOENT, use
              -e inject=chdir:error=ENOENT:when=3+.

              The valid range for numbers first and step is 1..65535,
              and for number last is 1..65534.

              An injection expression can contain only one error= or
              retval= specification, and only one signal= specification.
              If an injection expression contains multiple when=
              specifications, the last one takes precedence.

              Accounting of syscalls that are subject to injection is
              done per syscall and per tracee.

              Specification of syscall injection can be combined with
              other syscall filtering options, for example, -P
              /dev/urandom -e inject=file:error=ENOENT.

       -e fault=syscall_set[:error=errno][:when=expr]
       --fault=syscall_set[:error=errno][:when=expr]
              Perform syscall fault injection for the specified set of
              syscalls.

              This is equivalent to more generic -e inject= expression
              with default value of errno option set to ENOSYS.

   Miscellaneous
       -d
       --debug
              Show some debugging output of strace itself on the
              standard error.

       -F     This option is deprecated.  It is retained for backward
              compatibility only and may be removed in future releases.
              Usage of multiple instances of -F option is still
              equivalent to a single -f, and it is ignored at all if
              used along with one or more instances of -f option.

       -h
       --help Print the help summary.

       --seccomp-bpf
              Try to enable use of seccomp-bpf (see seccomp(2)) to have
              ptrace(2)-stops only when system calls that are being
              traced occur in the traced processes.

              This option has no effect unless -f/--follow-forks is also
              specified.  --seccomp-bpf is not compatible with
              --syscall-limit and -b/--detach-on options.  It is also
              not applicable to processes attached using -p/--attach
              option.

              An attempt to enable system calls filtering using seccomp-
              bpf may fail for various reasons, e.g. there are too many
              system calls to filter, the seccomp API is not available,
              or strace itself is being traced.  In cases when seccomp-
              bpf filter setup failed, strace proceeds as usual and
              stops traced processes on every system call.

              When --seccomp-bpf is activated and -p/--attach option is
              not used, --kill-on-exit option is activated as well.

              Note that in cases when the tracee has another seccomp
              filter that returns an action value with a precedence
              greater than SECCOMP_RET_TRACE, strace --seccomp-bpf will
              not be notified.  That is, if another seccomp filter, for
              example, disables the syscall or kills the tracee, then
              strace --seccomp-bpf will not be aware of that syscall
              invocation at all.

       --tips[=[[id:]id],[[format:]format]]
              Show strace tips, tricks, and tweaks before exit.  id can
              be a non-negative integer number, which enables printing
              of specific tip, trick, or tweak (these ID are not
              guaranteed to be stable), or random (the default), in
              which case a random tip is printed.  format can be one of
              the following:

              none    No tip is printed.  Can be used to override the
                      previous setting.
              compact  Print the tip just big enough to contain all the
                      text.
              full    Print the tip in its full glory.

              Default is id:random,format:compact.

       -V
       --version
              Print the version number of strace.  Multiple instances of
              the option beyond specific threshold tend to increase
              Strauss awareness.

  Time specification format description
       Time values can be specified as a decimal floating point number
       (in a format accepted by strtod(3)), optionally followed by one
       of the following suffices that specify the unit of time: s
       (seconds), ms (milliseconds), us (microseconds), or ns
       (nanoseconds).  If no suffix is specified, the value is
       interpreted as microseconds.

       The described format is used for -O, -e inject=delay_enter, and
       -e inject=delay_exit options.
DIAGNOSTICS
       When command exits, strace exits with the same exit status.  If
       command is terminated by a signal, strace terminates itself with
       the same signal, so that strace can be used as a wrapper process
       transparent to the invoking parent process.  Note that parent-
       child relationship (signal stop notifications, getppid(2) value,
       etc) between traced process and its parent are not preserved
       unless -D is used.

       When using -p without a command, the exit status of strace is
       zero unless no processes has been attached or there was an
       unexpected error in doing the tracing.
SETUID INSTALLATION
       If strace is installed setuid to root then the invoking user will
       be able to attach to and trace processes owned by any user.  In
       addition setuid and setgid programs will be executed and traced
       with the correct effective privileges.  Since only users trusted
       with full root privileges should be allowed to do these things,
       it only makes sense to install strace as setuid to root when the
       users who can execute it are restricted to those users who have
       this trust.  For example, it makes sense to install a special
       version of strace with mode 'rwsr-xr--', user root and group
       trace, where members of the trace group are trusted users.  If
       you do use this feature, please remember to install a regular
       non-setuid version of strace for ordinary users to use.
MULTIPLE PERSONALITIES SUPPORT
       On some architectures, strace supports decoding of syscalls for
       processes that use different ABI rather than the one strace uses.
       Specifically, in addition to decoding native ABI, strace can
       decode the following ABIs on the following architectures:

       [1]  When strace is built as an x86_64 application
       [2]  When strace is built as an x32 application
       [3]  Big-endian only

       This support is optional and relies on ability to generate and
       parse structure definitions during the build time.  Please refer
       to the output of the strace -V command in order to figure out
       what support is available in your strace build ("non-native"
       refers to an ABI that differs from the ABI strace has):

       m32-mpers
              strace can trace and properly decode non-native 32-bit
              binaries.
       no-m32-mpers
              strace can trace, but cannot properly decode non-native
              32-bit binaries.
       mx32-mpers
              strace can trace and properly decode non-native
              32-on-64-bit binaries.
       no-mx32-mpers
              strace can trace, but cannot properly decode non-native
              32-on-64-bit binaries.

       If the output contains neither m32-mpers nor no-m32-mpers, then
       decoding of non-native 32-bit binaries is not implemented at all
       or not applicable.

       Likewise, if the output contains neither mx32-mpers nor no-
       mx32-mpers, then decoding of non-native 32-on-64-bit binaries is
       not implemented at all or not applicable.
NOTES
       It is a pity that so much tracing clutter is produced by systems
       employing shared libraries.

       It is instructive to think about system call inputs and outputs
       as data-flow across the user/kernel boundary.  Because user-space
       and kernel-space are separate and address-protected, it is
       sometimes possible to make deductive inferences about process
       behavior using inputs and outputs as propositions.

       In some cases, a system call will differ from the documented
       behavior or have a different name.  For example, the faccessat(2)
       system call does not have flags argument, and the setrlimit(2)
       library function uses prlimit64(2) system call on modern
       (2.6.38+) kernels.  These discrepancies are normal but
       idiosyncratic characteristics of the system call interface and
```

```
␣␣␣␣␣␣␣are␣accounted␣for␣by␣C␣library␣wrapper␣functions.

␣␣␣␣␣␣␣Some␣system␣calls␣have␣different␣names␣in␣different␣architectures
␣␣␣␣␣␣␣and␣personalities.␣␣In␣these␣cases,␣system␣call␣filtering␣and
␣␣␣␣␣␣␣printing␣uses␣the␣names␣that␣match␣corresponding␣__NR_*␣kernel
␣␣␣␣␣␣␣macros␣of␣the␣tracee's␣architecture␣and␣personality.␣␣There␣are
␣␣␣␣␣␣␣two␣exceptions␣from␣this␣general␣rule:␣arm_fadvise64_64(2)␣ARM
␣␣␣␣␣␣␣syscall␣and␣xtensa_fadvise64_64(2)␣Xtensa␣syscall␣are␣filtered
␣␣␣␣␣␣␣and␣printed␣as␣fadvise64_64(2).

␣␣␣␣␣␣␣On␣x32,␣syscalls␣that␣are␣intended␣to␣be␣used␣by␣64-bit␣processes
␣␣␣␣␣␣␣and␣not␣x32␣ones␣(for␣example,␣readv(2),␣that␣has␣syscall␣number
␣␣␣␣␣␣␣19␣on␣x86_64,␣with␣its␣x32␣counterpart␣has␣syscall␣number␣515),
␣␣␣␣␣␣␣but␣called␣with␣__X32_SYSCALL_BIT␣flag␣being␣set,␣are␣designated
␣␣␣␣␣␣␣with␣#64␣suffix.

␣␣␣␣␣␣␣On␣some␣platforms␣a␣process␣that␣is␣attached␣to␣with␣the␣-p
␣␣␣␣␣␣␣option␣may␣observe␣a␣spurious␣EINTR␣return␣from␣the␣current
␣␣␣␣␣␣␣system␣call␣that␣is␣not␣restartable.␣␣(Ideally,␣all␣system␣calls
␣␣␣␣␣␣␣should␣be␣restarted␣on␣strace␣attach,␣making␣the␣attach␣invisible
␣␣␣␣␣␣␣to␣the␣traced␣process,␣but␣a␣few␣system␣calls␣aren't.␣␣Arguably,
␣␣␣␣␣␣␣every␣instance␣of␣such␣behavior␣is␣a␣kernel␣bug.)␣␣This␣may␣have
␣␣␣␣␣␣␣an␣unpredictable␣effect␣on␣the␣process␣if␣the␣process␣takes␣no
␣␣␣␣␣␣␣action␣to␣restart␣the␣system␣call.

␣␣␣␣␣␣␣As␣strace␣executes␣the␣specified␣command␣directly␣and␣does␣not
␣␣␣␣␣␣␣employ␣a␣shell␣for␣that,␣scripts␣without␣shebang␣that␣usually␣run
␣␣␣␣␣␣␣just␣fine␣when␣invoked␣by␣shell␣fail␣to␣execute␣with␣ENOEXEC
␣␣␣␣␣␣␣error.␣␣It␣is␣advisable␣to␣manually␣supply␣a␣shell␣as␣a␣command
␣␣␣␣␣␣␣with␣the␣script␣as␣its␣argument.
BUGS
␣␣␣␣␣␣␣Programs␣that␣use␣the␣setuid␣bit␣do␣not␣have␣effective␣user␣ID
␣␣␣␣␣␣␣privileges␣while␣being␣traced.

␣␣␣␣␣␣␣A␣traced␣process␣runs␣slowly␣(but␣check␣out␣the␣--seccomp-bpf
␣␣␣␣␣␣␣option).

␣␣␣␣␣␣␣Unless␣--kill-on-exit␣option␣is␣used␣(or␣--seccomp-bpf␣option␣is
␣␣␣␣␣␣␣used␣in␣a␣way␣that␣implies␣--kill-on-exit),␣traced␣processes
␣␣␣␣␣␣␣which␣are␣descended␣from␣command␣may␣be␣left␣running␣after␣an
␣␣␣␣␣␣␣interrupt␣signal␣(CTRL-C).

␣␣␣␣␣␣␣By␣using␣CLONE_UNTRACED␣flag␣of␣clone␣system␣call␣a␣tracee␣can
␣␣␣␣␣␣␣break␣the␣guarantee␣that␣--seccomp-bpf␣will␣not␣leave␣any
␣␣␣␣␣␣␣processes␣with␣a␣seccomp␣program␣installed␣for␣syscall␣filtering
␣␣␣␣␣␣␣purposes.
HISTORY
␣␣␣␣␣␣␣The␣original␣strace␣was␣written␣by␣Paul␣Kranenburg␣for␣SunOS␣and
␣␣␣␣␣␣␣was␣inspired␣by␣its␣trace␣utility.␣␣The␣SunOS␣version␣of␣strace
␣␣␣␣␣␣␣was␣ported␣to␣Linux␣and␣enhanced␣by␣Branko␣Lankester,␣who␣also
␣␣␣␣␣␣␣wrote␣the␣Linux␣kernel␣support.␣␣Even␣though␣Paul␣released␣strace
␣␣␣␣␣␣␣2.5␣in␣1992,␣Branko's␣work␣was␣based␣on␣Paul's␣strace␣1.5␣release
␣␣␣␣␣␣␣from␣1991.␣␣In␣1993,␣Rick␣Sladkey␣merged␣strace␣2.5␣for␣SunOS␣and
␣␣␣␣␣␣␣the␣second␣release␣of␣strace␣for␣Linux,␣added␣many␣of␣the
␣␣␣␣␣␣␣features␣of␣truss(1)␣from␣SVR4,␣and␣produced␣an␣strace␣that
␣␣␣␣␣␣␣worked␣on␣both␣platforms.␣␣In␣1994␣Rick␣ported␣strace␣to␣SVR4␣and
␣␣␣␣␣␣␣Solaris␣and␣wrote␣the␣automatic␣configuration␣support.␣␣In␣1995
␣␣␣␣␣␣␣he␣ported␣strace␣to␣Irix␣and␣became␣tired␣of␣writing␣about
␣␣␣␣␣␣␣himself␣in␣the␣third␣person.

␣␣␣␣␣␣␣Beginning␣with␣1996,␣strace␣was␣maintained␣by␣Wichert␣Akkerman.
␣␣␣␣␣␣␣During␣his␣tenure,␣strace␣development␣migrated␣to␣CVS;␣ports␣to
␣␣␣␣␣␣␣FreeBSD␣and␣many␣architectures␣on␣Linux␣(including␣ARM,␣IA-64,
␣␣␣␣␣␣␣MIPS,␣PA-RISC,␣PowerPC,␣s390,␣SPARC)␣were␣introduced.␣␣In␣2002,
␣␣␣␣␣␣␣the␣burden␣of␣strace␣maintainership␣was␣transferred␣to␣Roland
␣␣␣␣␣␣␣McGrath.␣␣Since␣then,␣strace␣gained␣support␣for␣several␣new␣Linux
␣␣␣␣␣␣␣architectures␣(AMD64,␣s390x,␣SuperH),␣bi-architecture␣support␣for
␣␣␣␣␣␣␣some␣of␣them,␣and␣received␣numerous␣additions␣and␣improvements␣in
␣␣␣␣␣␣␣syscalls␣decoders␣on␣Linux;␣strace␣development␣migrated␣to␣Git
␣␣␣␣␣␣␣during␣that␣period.␣␣Since␣2009,␣strace␣is␣actively␣maintained␣by
␣␣␣␣␣␣␣Dmitry␣Levin.␣␣strace␣gained␣support␣for␣AArch64,␣ARC,␣AVR32,
␣␣␣␣␣␣␣Blackfin,␣Meta,␣Nios␣II,␣OpenRISC␣1000,␣RISC-V,␣Tile/TileGx,
␣␣␣␣␣␣␣Xtensa␣architectures␣since␣that␣time.␣␣In␣2012,␣unmaintained␣and
␣␣␣␣␣␣␣apparently␣broken␣support␣for␣non-Linux␣operating␣systems␣was
␣␣␣␣␣␣␣removed.␣␣Also,␣in␣2012␣strace␣gained␣support␣for␣path␣tracing
␣␣␣␣␣␣␣and␣file␣descriptor␣path␣decoding.␣␣In␣2014,␣support␣for␣stack
␣␣␣␣␣␣␣trace␣printing␣was␣added.␣␣In␣2016,␣syscall␣fault␣injection␣was
␣␣␣␣␣␣␣implemented.

␣␣␣␣␣␣␣For␣the␣additional␣information,␣please␣refer␣to␣the␣NEWS␣file␣and
␣␣␣␣␣␣␣strace␣repository␣commit␣log.
REPORTING␣BUGS
␣␣␣␣␣␣␣Problems␣with␣strace␣should␣be␣reported␣to␣the␣strace␣mailing
␣␣␣␣␣␣␣list␣mailto:strace-devel@lists.strace.io.
SEE␣ALSO
␣␣␣␣␣␣␣strace-log-merge(1),␣ltrace(1),␣perf-trace(1),␣trace-cmd(1),
␣␣␣␣␣␣␣time(1),␣ptrace(2),␣seccomp(2),␣syscall(2),␣proc(5),␣signal(7)

␣␣␣␣␣␣␣strace␣Home␣Page␣https://strace.io/
AUTHORS
␣␣␣␣␣␣␣The␣complete␣list␣of␣strace␣contributors␣can␣be␣found␣in␣the
␣␣␣␣␣␣␣CREDITS␣file.
```

```
COLOPHON
␣␣␣␣␣␣␣This␣page␣is␣part␣of␣the␣strace␣(system␣call␣tracer)␣project.
␣␣␣␣␣␣␣Information␣about␣the␣project␣can␣be␣found␣at
␣␣␣␣␣␣␣http://strace.io/.␣␣If␣you␣have␣a␣bug␣report␣for␣this␣manual
␣␣␣␣␣␣␣page,␣send␣it␣to␣strace-devel@lists.sourceforge.net.␣␣This␣page
␣␣␣␣␣␣␣was␣obtained␣from␣the␣project's␣upstream␣Git␣repository
␣␣␣␣␣␣␣https://github.com/strace/strace.git␣on␣2024-06-14.␣␣(At␣that
␣␣␣␣␣␣␣time,␣the␣date␣of␣the␣most␣recent␣commit␣that␣was␣found␣in␣the
␣␣␣␣␣␣␣repository␣was␣2024-06-04.)␣␣If␣you␣discover␣any␣rendering
␣␣␣␣␣␣␣problems␣in␣this␣HTML␣version␣of␣the␣page,␣or␣you␣believe␣there
␣␣␣␣␣␣␣is␣a␣better␣or␣more␣up-to-date␣source␣for␣the␣page,␣or␣you␣have
␣␣␣␣␣␣␣corrections␣or␣improvements␣to␣the␣information␣in␣this␣COLOPHON
␣␣␣␣␣␣␣(which␣is␣not␣part␣of␣the␣original␣manual␣page),␣send␣a␣mail␣to
␣␣␣␣␣␣␣man-pages@man7.org

strace␣6.9.0.16.2a4c4␣␣␣␣␣␣␣␣␣␣2024-06-04␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣STRACE(1)
```

3.10 `strings`: Print Sequences Of Printable Characters

```
NAME
       strings - print the sequences of printable characters in files
SYNOPSIS
       strings [-afovV] [-min-len]
               [-n min-len] [--bytes=min-len]
               [-t radix] [--radix=radix]
               [-e encoding] [--encoding=encoding]
               [-U method] [--unicode=method]
               [-] [--all] [--print-file-name]
               [-T bfdname] [--target=bfdname]
               [-w] [--include-all-whitespace]
               [-s] [--output-separator sep_string]
               [--help] [--version] file...
DESCRIPTION
       For each file given, GNU strings prints the printable character
       sequences that are at least 4 characters long (or the number
       given with the options below) and are followed by an unprintable
       character.

       Depending upon how the strings program was configured it will
       default to either displaying all the printable sequences that it
       can find in each file, or only those sequences that are in
       loadable, initialized data sections.  If the file type is
       unrecognizable, or if strings is reading from stdin then it will
       always display all of the printable sequences that it can find.

       For backwards compatibility any file that occurs after a command-
       line option of just - will also be scanned in full, regardless of
       the presence of any -d option.

       strings is mainly useful for determining the contents of non-text
       files.
OPTIONS
       -a
       --all
       -   Scan the whole file, regardless of what sections it contains
           or whether those sections are loaded or initialized.
           Normally this is the default behaviour, but strings can be
           configured so that the -d is the default instead.

           The - option is position dependent and forces strings to
           perform full scans of any file that is mentioned after the -
           on the command line, even if the -d option has been
           specified.

       -d
       --data
           Only print strings from initialized, loaded data sections in
           the file.  This may reduce the amount of garbage in the
           output, but it also exposes the strings program to any
           security flaws that may be present in the BFD library used to
           scan and load sections.  Strings can be configured so that
           this option is the default behaviour.  In such cases the -a
           option can be used to avoid using the BFD library and instead
           just print all of the strings found in the file.

       -f
       --print-file-name
           Print the name of the file before each string.

       --help
           Print a summary of the program usage on the standard output
           and exit.

       -min-len
       -n min-len
       --bytes=min-len
           Print sequences of displayable characters that are at least
           min-len characters long.  If not specified a default minimum
           length of 4 is used.  The distinction between displayable and
           non-displayable characters depends upon the setting of the -e
           and -U options.  Sequences are always terminated at control
           characters such as new-line and carriage-return, but not the
           tab character.

       -o  Like -t o.  Some other versions of strings have -o act like
           -t d instead.  Since we can not be compatible with both ways,
           we simply chose one.

       -t radix
       --radix=radix
           Print the offset within the file before each string.  The
           single character argument specifies the radix of the
           offset---o for octal, x for hexadecimal, or d for decimal.

       -e encoding
       --encoding=encoding
           Select the character encoding of the strings that are to be
           found.  Possible values for encoding are: s =
           single-7-bit-byte characters (default), S = single-8-bit-byte
           characters, b = 16-bit bigendian, l = 16-bit littleendian, B
           = 32-bit bigendian, L = 32-bit littleendian.  Useful for
           finding wide character strings. (l and b apply to, for
           example, Unicode UTF-16/UCS-2 encodings).

       -U [d|i|l|e|x|h]
       --unicode=[default|invalid|locale|escape|hex|highlight]
           Controls the display of UTF-8 encoded multibyte characters in
           strings.  The default (--unicode=default) is to give them no
           special treatment, and instead rely upon the setting of the
           --encoding option.  The other values for this option
           automatically enable --encoding=S.

           The --unicode=invalid option treats them as non-graphic
           characters and hence not part of a valid string.  All the
           remaining options treat them as valid string characters.

           The --unicode=locale option displays them in the current
           locale, which may or may not support UTF-8 encoding.  The
           --unicode=hex option displays them as hex byte sequences
           enclosed between <> characters.  The --unicode=escape option
           displays them as escape sequences (\uxxxx) and the
           --unicode=highlight option displays them as escape sequences
           highlighted in red (if supported by the output device).  The
           colouring is intended to draw attention to the presence of
           unicode sequences where they might not be expected.

       -T bfdname
       --target=bfdname
           Specify an object code format other than your system's
␣␣␣␣␣␣␣␣␣␣␣default␣format.

␣␣␣␣␣␣␣-v
␣␣␣␣␣␣␣-V
␣␣␣␣␣␣␣--version
␣␣␣␣␣␣␣␣␣␣␣Print␣the␣program␣version␣number␣on␣the␣standard␣output␣and
␣␣␣␣␣␣␣␣␣␣␣exit.

␣␣␣␣␣␣␣-w
␣␣␣␣␣␣␣--include-all-whitespace
␣␣␣␣␣␣␣␣␣␣␣By␣default␣tab␣and␣space␣characters␣are␣included␣in␣the
␣␣␣␣␣␣␣␣␣␣␣strings␣that␣are␣displayed,␣but␣other␣whitespace␣characters,
␣␣␣␣␣␣␣␣␣␣␣such␣a␣newlines␣and␣carriage␣returns,␣are␣not.␣␣The␣-w␣option
␣␣␣␣␣␣␣␣␣␣␣changes␣this␣so␣that␣all␣whitespace␣characters␣are␣considered
␣␣␣␣␣␣␣␣␣␣␣to␣be␣part␣of␣a␣string.

␣␣␣␣␣␣␣-s
␣␣␣␣␣␣␣--output-separator
␣␣␣␣␣␣␣␣␣␣␣By␣default,␣output␣strings␣are␣delimited␣by␣a␣new-line.␣This
␣␣␣␣␣␣␣␣␣␣␣option␣allows␣you␣to␣supply␣any␣string␣to␣be␣used␣as␣the
␣␣␣␣␣␣␣␣␣␣␣output␣record␣separator.␣␣Useful␣with
␣␣␣␣␣␣␣␣␣␣␣--include-all-whitespace␣where␣strings␣may␣contain␣new-lines
␣␣␣␣␣␣␣␣␣␣␣internally.

␣␣␣␣␣␣␣@file
␣␣␣␣␣␣␣␣␣␣␣Read␣command-line␣options␣from␣file.␣␣The␣options␣read␣are
␣␣␣␣␣␣␣␣␣␣␣inserted␣in␣place␣of␣the␣original␣@file␣option.␣␣If␣file␣does
␣␣␣␣␣␣␣␣␣␣␣not␣exist,␣or␣cannot␣be␣read,␣then␣the␣option␣will␣be␣treated
␣␣␣␣␣␣␣␣␣␣␣literally,␣and␣not␣removed.

␣␣␣␣␣␣␣␣␣␣␣Options␣in␣file␣are␣separated␣by␣whitespace.␣␣A␣whitespace
␣␣␣␣␣␣␣␣␣␣␣character␣may␣be␣included␣in␣an␣option␣by␣surrounding␣the
␣␣␣␣␣␣␣␣␣␣␣entire␣option␣in␣either␣single␣or␣double␣quotes.␣␣Any
␣␣␣␣␣␣␣␣␣␣␣character␣(including␣a␣backslash)␣may␣be␣included␣by
␣␣␣␣␣␣␣␣␣␣␣prefixing␣the␣character␣to␣be␣included␣with␣a␣backslash.␣␣The
␣␣␣␣␣␣␣␣␣␣␣file␣may␣itself␣contain␣additional␣@file␣options;␣any␣such
␣␣␣␣␣␣␣␣␣␣␣options␣will␣be␣processed␣recursively.
SEE␣ALSO
␣␣␣␣␣␣␣ar(1),␣nm(1),␣objdump(1),␣ranlib(1),␣readelf(1)␣and␣the␣Info
␣␣␣␣␣␣␣entries␣for␣binutils.
COPYRIGHT
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