trace your binaries with uftrace

2022 CodeEngn Conference 18

Kang Minchul

2022. 7. 4.

Who am I

- Open Source Developer (現)
- Lecturer & Writer (現)
- Penta Security Systems Inc. (前)
- Open Source Consulting Inc. (前)

Contents

- uftrace: introduction
- basic usage
- tracing open sources-1 : git
- advanced usage – full dynamic tracing
- tracing open sources-2 : nmap
- insights from uftrace

Contents

- uftrace: introduction
- basic usage
- tracing open sources-1 : git
- advanced usage – full dynamic tracing
- tracing open sources-2 : nmap
- insights from uftrace

Contents

- uftrace: introduction
- basic usage
- tracing open sources-1 : git
- advanced usage – full dynamic tracing
- tracing open sources-2 : nmap
- insights from uftrace

Contents

- uftrace: introduction
- basic usage
- tracing open sources-1 : git
- advanced usage – full dynamic tracing
- tracing open sources-2 : nmap
- insights from uftrace

Contents

- uftrace: introduction
- basic usage
- tracing open sources-1 : git
- advanced usage – full dynamic tracing
- tracing open sources-2 : nmap
- insights from uftrace

Contents

- uftrace: introduction
- basic usage
- tracing open sources-1 : git
- advanced usage – full dynamic tracing
- tracing open sources-2 : nmap
- insights from uftrace

Contents

- uftrace: introduction
- basic usage
- tracing open sources-1 : git
- advanced usage – full dynamic tracing
- tracing open sources-2 : nmap
- insights from uftrace

uftrace: introduction

A function (graph) tracer

https://github.com/namhyung/uftrace

uftrace: introduction

A function (graph) tracer for C/C++/Rust userspace programs in linux

https://github.com/namhyung/uftrace

uftrace: introduction

```
$ git clone https://github.com/namhyung/uftrace && cd uftrace
```

```
$ ./configure
uftrace detected system features:
...         prefix: /usr/local
...         libelf: [ on  ] - more flexible ELF data handling
...          libdw: [ OFF ] - DWARF debug info support
...   libpython2.7: [ OFF ] - python scripting support
...    libncursesw: [ OFF ] - TUI support
...   cxa_demangle: [ on  ] - full demangler support with libstdc++
...     perf_event: [ on  ] - perf (PMU) event support
...       schedule: [ on  ] - scheduler event support
...       capstone: [ OFF ] - full dynamic tracing support

$ make

$ sudo make install
```

uftrace: introduction

```
$ git clone https://github.com/namhyung/uftrace && cd uftrace

# To install required packages
$ sudo ./misc/install-deps.sh

$ ./configure
uftrace detected system features:
...         prefix: /usr/local
...         libelf: [ on  ] - more flexible ELF data handling
...          libdw: [ on  ] - DWARF debug info support
...   libpython2.7: [ on  ] - python scripting support
...    libncursesw: [ on  ] - TUI support
...   cxa_demangle: [ on  ] - full demangler support with libstdc++
...     perf_event: [ on  ] - perf (PMU) event support
...       schedule: [ on  ] - scheduler event support
...       capstone: [ on  ] - full dynamic tracing support

$ make

$ sudo make install
```

uftrace: introduction

```
$ cat foobar.c
void bar() {

}

void foo() {
  bar();
}

int main() {
  foo();
  bar();
}
```

```
$ gcc foobar.c
<bar>:

  ret


<foo>:

  call <bar>
  ret


<main>:

  call <foo>
  call <bar>
  ret
```

uftrace: introduction

```
$ cat foobar.c
void bar() {

}

void foo() {
  bar();
}

int main() {
  foo();
  bar();
}
```

```
$ gcc -pg foobar.c
<bar>:
  call <mcount@plt>
  ret


<foo>:
  call <mcount@plt>
  call <bar>
  ret


<main>:
  call <mcount@plt>
  call <foo>
  call <bar>
  ret
```

uftrace: introduction

```
$ cat foobar.c
void bar() {

}

void foo() {
  bar();
}

int main() {
  foo();
  bar();
}
```

```
$ gcc -finstrument-functions foobar.c
<bar>:
  call <__cyg_profile_func_enter@plt>
  call <__cyg_profile_func_exit@plt>
  ret

<foo>:
  call <__cyg_profile_func_enter@plt>
  call <bar>
  call <__cyg_profile_func_exit@plt>
  ret

<main>:
  call <__cyg_profile_func_enter@plt>
  call <foo>
  call <bar>
  call <__cyg_profile_func_exit@plt>
  ret
```

uftrace: introduction

```c
#include <stdio.h>

int bar(int b)
{
        printf("bar %d\n", b);
        return b;
}

int foo(int a)
{
        printf("foo %d\n", a);
        return bar(a+1);
}

void main(int argc, char *argv[])
{
        printf("hello %d\n", foo(argc));
}
```

uftrace: introduction

```
minchul@minchul:~/workspace$ objdump -d a.out
...

0000000000000934 <bar>:
 934:   a9be7bfd        stp     x29, x30, [sp, #-32]!
 938:   910003fd        mov     x29, sp
 93c:   aa1e03e1        mov     x1, x30
 940:   b9001fe0        str     w0, [sp, #28]
 944:   aa0103fe        mov     x30, x1
 948:   d50320ff        xpaclri
 94c:   aa1e03e0        mov     x0, x30
 950:   97ffff98        bl      7b0 <_mcount@plt>
 954:   b9401fe1        ldr     w1, [sp, #28]
 958:   90000000        adrp    x0, 0 <__abi_tag-0x278>
 95c:   9128e000        add     x0, x0, #0xa38
 960:   97ffff8c        bl      790 <printf@plt>
 964:   b9401fe0        ldr     w0, [sp, #28]
 968:   a8c27bfd        ldp     x29, x30, [sp], #32
 96c:   d65f03c0        ret
```

```
0000000000000970 <foo>:
 970:   a9be7bfd        stp     x29, x30, [sp, #-32]!
 974:   910003fd        mov     x29, sp
 978:   aa1e03e1        mov     x1, x30
 97c:   b9001fe0        str     w0, [sp, #28]
 980:   aa0103fe        mov     x30, x1
 984:   d50320ff        xpaclri
 988:   aa1e03e0        mov     x0, x30
 98c:   97ffff89        bl      7b0 <_mcount@plt>
 990:   b9401fe1        ldr     w1, [sp, #28]
 994:   90000000        adrp    x0, 0 <__abi_tag-0x278>
 998:   91290000        add     x0, x0, #0xa40
 99c:   97ffff7d        bl      790 <printf@plt>
 9a0:   b9401fe0        ldr     w0, [sp, #28]
 9a4:   11000400        add     w0, w0, #0x1
 9a8:   97ffffe3        bl      934 <bar>
 9ac:   a8c27bfd        ldp     x29, x30, [sp], #32
 9b0:   d65f03c0        ret
```

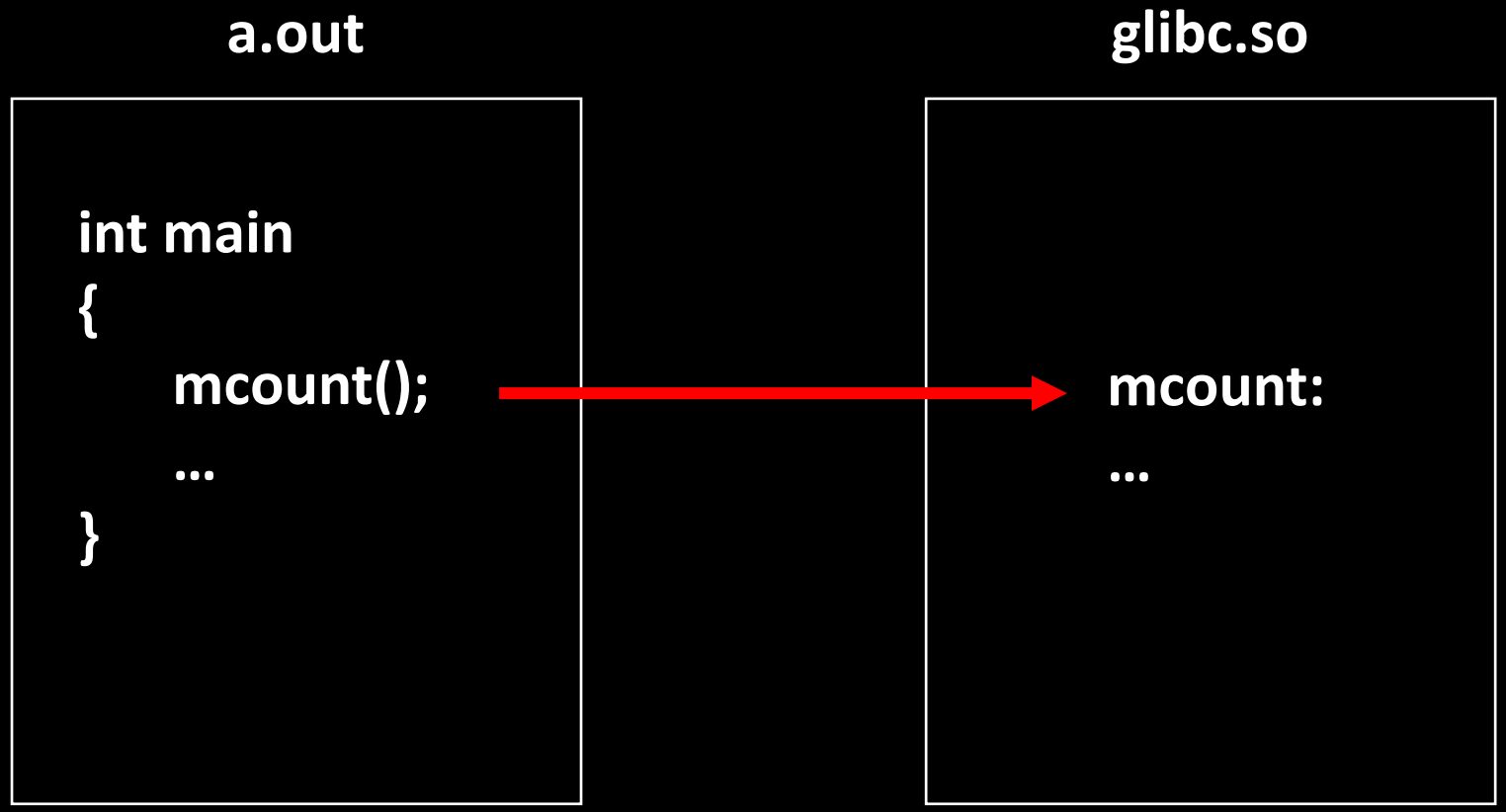
```
00000000000009b4 <main>:
 9b4:   a9be7bfd        stp     x29, x30, [sp, #-32]!
 9b8:   910003fd        mov     x29, sp
 9bc:   aa1e03e2        mov     x2, x30
 9c0:   b9001fe0        str     w0, [sp, #28]
 9c4:   f9000be1        str     x1, [sp, #16]
 9c8:   aa0203fe        mov     x30, x2
 9cc:   d50320ff        xpaclri
 9d0:   aa1e03e0        mov     x0, x30
 9d4:   97ffff77        bl      7b0 <_mcount@plt>
 9d8:   b9401fe0        ldr     w0, [sp, #28]
 9dc:   97fffe5         bl      970 <foo>
 9e0:   2a0003e1        mov     w1, w0
 9e4:   90000000        adrp    x0, 0 <__abi_tag-0x278>
 9e8:   91292000        add     x0, x0, #0xa48
 9ec:   97ffff69        bl      790 <printf@plt>
 9f0:   d503201f        nop
 9f4:   a8c27bfd        ldp     x29, x30, [sp], #32
 9f8:   d65f03c0        ret
 9fc:   d503201f        nop
```

uftrace: introduction

Architecture	GCC options	Trace function
x86	-pg	mcount()
x86	-pg -mfentry	__ fentry__()
x86	-finstrument-functions	_cyg_profile_func{enter, exit}
ARM	-pg	__gnu_mcount_nc()
AArch64	-pg	_mcount()

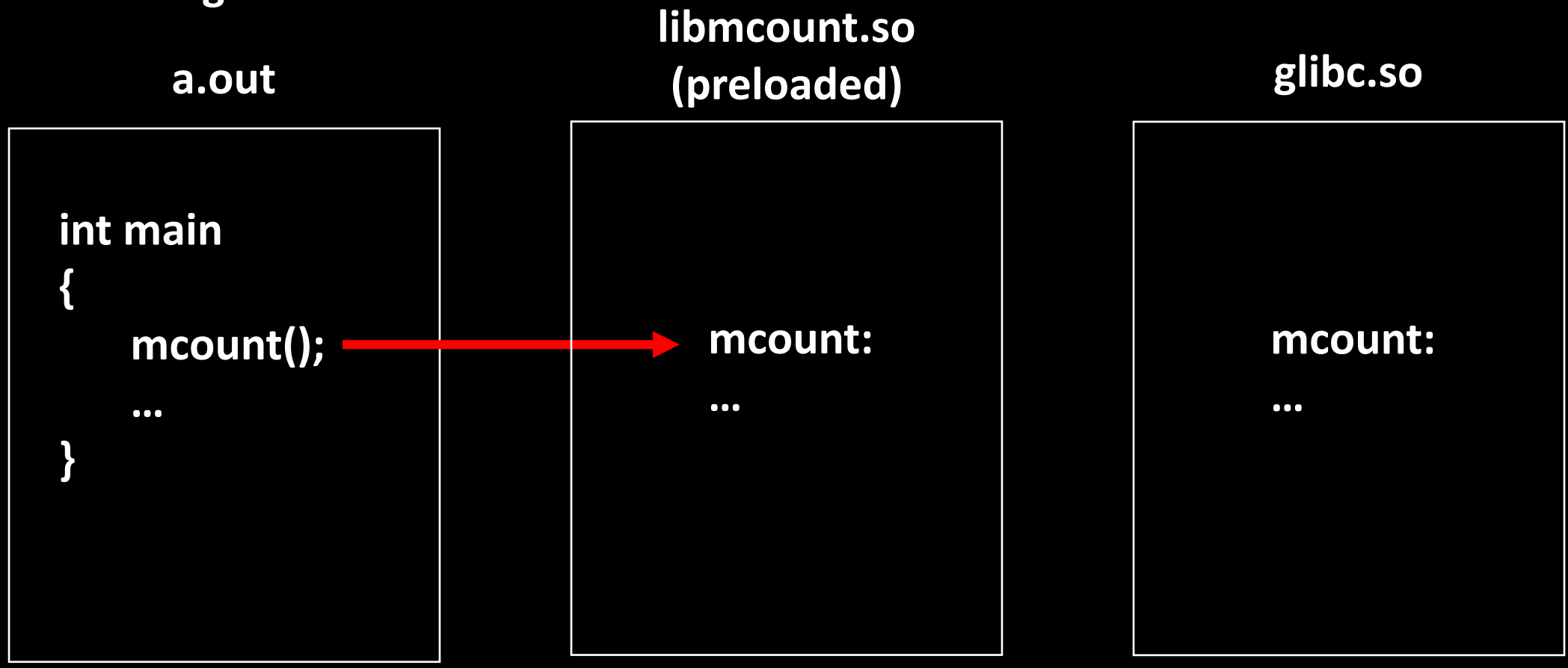
uftrace: introduction

a.out running without uftrace



uftrace: introduction

a.out running with uftrace



Basic usage

$ uftrace [COMMAND] [OPTION...] [<program>]

Basic usage

$ uftrace [COMMAND] [OPTION...] [<program>]

record	Run a program and saves the trace data
replay	Show program execution in the trace data
live	Do record and replay in a row (default)
report	Show performance statistics in the trace data
dump	Show low-level trace data
graph	Show function call graph in the trace data
tui	Show text user interface for graph and report
info	Show system and program info in the trace data
recv	Save the trace data from network
script	Run a script for recorded trace data

Basic usage

$ uftrace [COMMAND] [OPTION...] [<program>]

record	Run a program and saves the trace data
replay	Show program execution in the trace data
live	Do record and replay in a row (default)
report	Show performance statistics in the trace data
dump	Show low-level trace data
graph	Show function call graph in the trace data
tui	Show text user interface for graph and report
info	Show system and program info in the trace data
recv	Save the trace data from network
script	Run a script for recorded trace data

Basic usage

$ uftrace [COMMAND] [OPTION...] [<program>]

record Run a program and saves the trace data

So many Options Avaliable

recv Save the trace data from network
script Run a script for recorded trace data

Basic usage

$ uftrace [COMMAND] [OPTION...] [<program>]

record	Run a program and saves the trace data
replay	Show program execution in the trace data
live	Do record and replay in a row (default)
report	Show performance statistics in the trace data
dump	Show low-level trace data
graph	Show function call graph in the trace data
tui	Show text user interface for graph and report
info	Show system and program info in the trace data
recv	Save the trace data from network
script	Run a script for recorded trace data

Basic usage – record & replay

Basic usage – record & replay

-D DEPTH, --depth=DEPTH : Set global trace limit in nesting level.

```
minchul@minchul:~/workspace/examples$ ls
a.out  foo.c
minchul@minchul:~/workspace/examples$ uftrace record -D 2 a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   1.595 us [  5911] | __monstartup();
   0.854 us [  5911] | __cxa_atexit();
            [  5911] | main() {
   0.805 us [  5911] |   a();
   2.414 us [  5911] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -D 3 a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   1.812 us [  5924] | __monstartup();
   0.832 us [  5924] | __cxa_atexit();
            [  5924] | main() {
            [  5924] |   a() {
   0.743 us [  5924] |     b();
   2.367 us [  5924] |   } /* a */
   3.812 us [  5924] | } /* main */
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

-D DEPTH, --depth=DEPTH : Set global trace limit in nesting level.

```
minchul@minchul:~/workspace/examples$ ls
a.out  foo.c
minchul@minchul:~/workspace/examples$ uftrace record -D 2 a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   1.595 us [  5911] | __monstartup();
   0.854 us [  5911] | __cxa_atexit();
            [  5911] | main() {
   0.805 us [  5911] |   a();
   2.414 us [  5911] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -D 3 a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   1.812 us [  5924] | __monstartup();
   0.832 us [  5924] | __cxa_atexit();
            [  5924] | main() {
            [  5924] |   a() {
   0.743 us [  5924] |     b();
   2.367 us [  5924] |   } /* a */
   3.812 us [  5924] | } /* main */
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

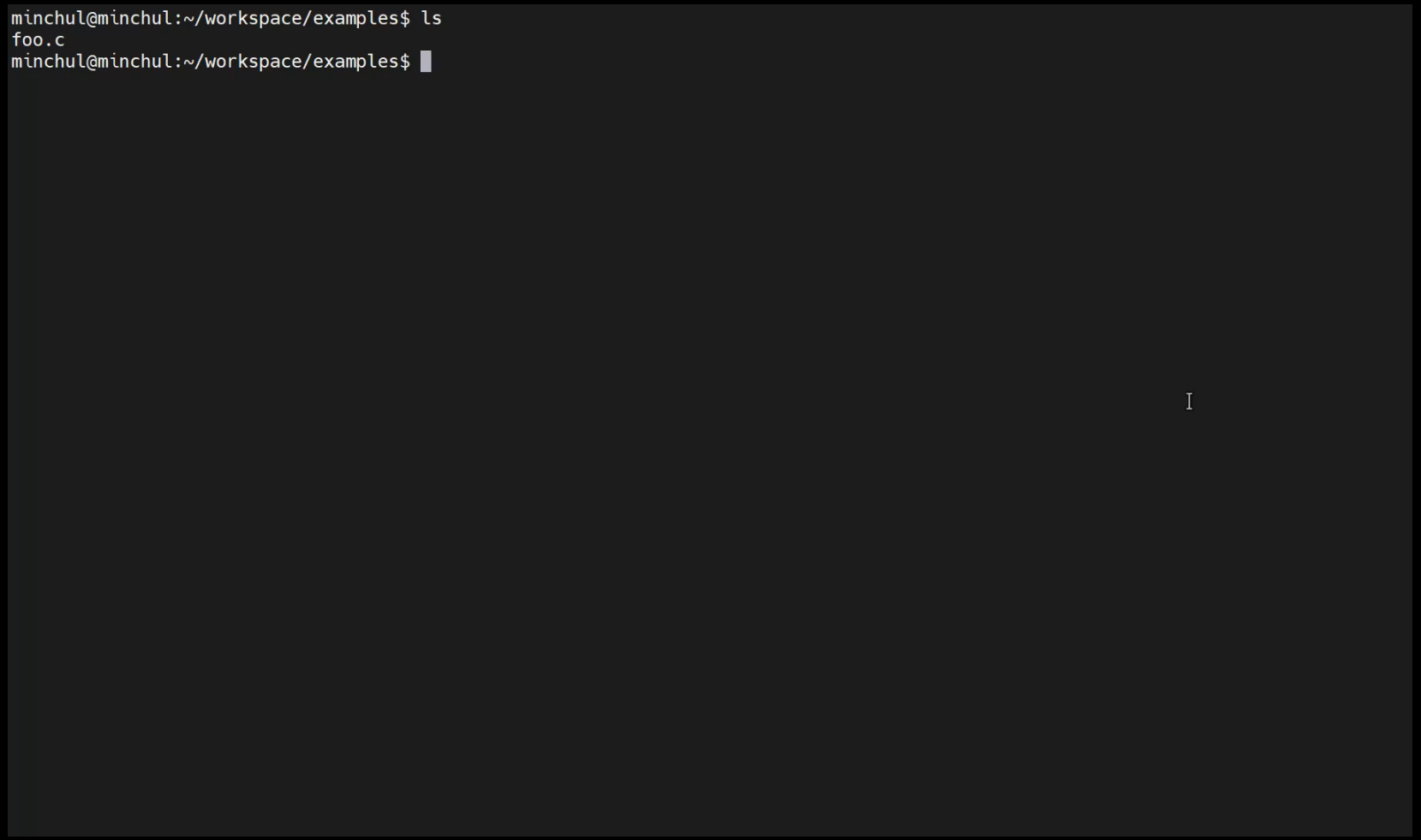
-D DEPTH, --depth=DEPTH : Set global trace limit in nesting level.

```
minchul@minchul:~/workspace/examples$ ls
a.out  foo.c
minchul@minchul:~/workspace/examples$ uftrace record -D 2 a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   1.595 us [  5911] | __monstartup();
   0.854 us [  5911] | __cxa_atexit();
            [  5911] | main() {
   0.805 us [  5911] |   a();
   2.414 us [  5911] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -D 3 a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   1.812 us [  5924] | __monstartup();
   0.832 us [  5924] | __cxa_atexit();
            [  5924] | main() {
            [  5924] |   a() {
   0.743 us [  5924] |     b();
   2.367 us [  5924] |   } /* a */
   3.812 us [  5924] | } /* main */
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

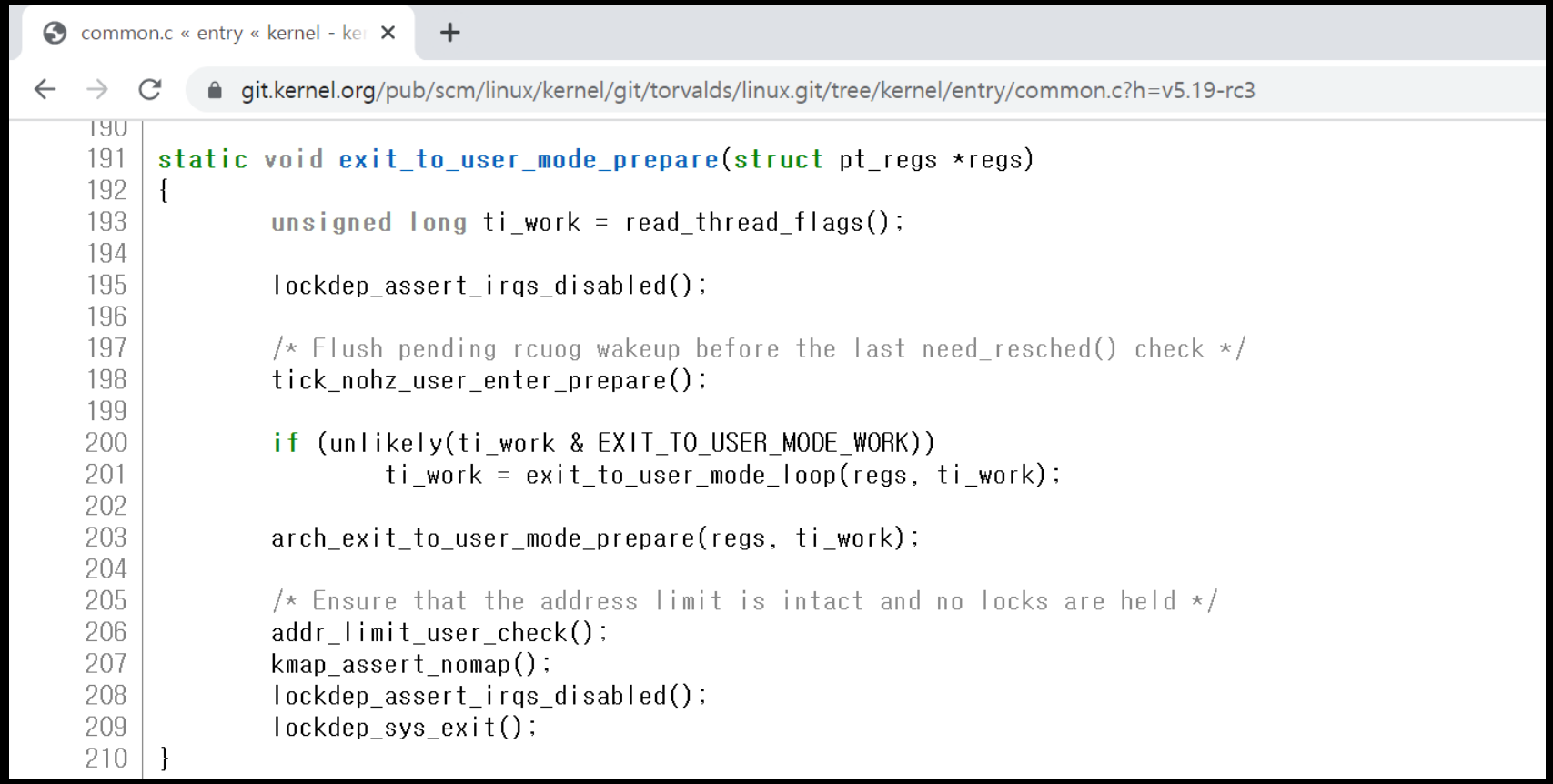
-k, --kernel : Trace kernel functions as well as user functions.



See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

-k, --kernel : Trace kernel functions as well as user functions.




```
190
191 static void exit_to_user_mode_prepare(struct pt_regs *regs)
192 {
193         unsigned long ti_work = read_thread_flags();
194
195         lockdep_assert_irqs_disabled();
196
197         /* Flush pending rcuog wakeup before the last need_resched() check */
198         tick_nohz_user_enter_prepare();
199
200         if (unlikely(ti_work & EXIT_TO_USER_MODE_WORK))
201                 ti_work = exit_to_user_mode_loop(regs, ti_work);
202
203         arch_exit_to_user_mode_prepare(regs, ti_work);
204
205         /* Ensure that the address limit is intact and no locks are held */
206         addr_limit_user_check();
207         kmap_assert_nomap();
208         lockdep_assert_irqs_disabled();
209         lockdep_sys_exit();
210 }
```

See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

-F FUNC, --filter=FUNC : Set filter to trace selected functions and their children functions.

```
minchul@minchul:~/workspace/examples$ uftrace record -F a a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  6764] | a() {
            [  6764] |   b() {
   0.652 us [  6764] |     c();
   2.878 us [  6764] |   } /* b */
   4.631 us [  6764] | } /* a */
minchul@minchul:~/workspace/examples$ uftrace record -F b a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  6771] | b() {
   0.765 us [  6771] |   c();
   3.440 us [  6771] | } /* b */
minchul@minchul:~/workspace/examples$ uftrace record -F c a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   0.878 us [  6781] | c();
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

-F FUNC, --filter=FUNC : Set filter to trace selected functions and their children functions.

```
minchul@minchul:~/workspace/examples$ uftrace record -F a a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  6764] | a() {
            [  6764] |   b() {
   0.652 us [  6764] |     c();
   2.878 us [  6764] |   } /* b */
   4.631 us [  6764] | } /* a */
minchul@minchul:~/workspace/examples$ uftrace record -F b a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  6771] | b() {
   0.765 us [  6771] |   c();
   3.440 us [  6771] | } /* b */
minchul@minchul:~/workspace/examples$ uftrace record -F c a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   0.878 us [  6781] | c();
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

-F FUNC, --filter=FUNC : Set filter to trace selected functions and their children functions.

```
minchul@minchul:~/workspace/examples$ uftrace record -F a a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  6764] | a() {
            [  6764] |   b() {
   0.652 us [  6764] |     c();
   2.878 us [  6764] |   } /* b */
   4.631 us [  6764] | } /* a */
minchul@minchul:~/workspace/examples$ uftrace record -F b a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  6771] | b() {
   0.765 us [  6771] |   c();
   3.440 us [  6771] | } /* b */
minchul@minchul:~/workspace/examples$ uftrace record -F c a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   0.878 us [  6781] | c();
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

-F FUNC, --filter=FUNC : Set filter to trace selected functions and their children functions.

```
minchul@minchul:~/workspace/examples$ uftrace record -F a a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  6764] | a() {
            [  6764] |   b() {
   0.652 us [  6764] |     c();
   2.878 us [  6764] |   } /* b */
   4.631 us [  6764] | } /* a */
minchul@minchul:~/workspace/examples$ uftrace record -F b a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  6771] | b() {
   0.765 us [  6771] |   c();
   3.440 us [  6771] | } /* b */
minchul@minchul:~/workspace/examples$ uftrace record -F c a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   0.878 us [  6781] | c();
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

-N FUNC, --notrace=FUNC : Set filter not to trace selected functions and their children functions.

```
minchul@minchul:~/workspace/examples$ uftrace record -N c a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   1.673 us [  6848] | __monstartup();
   0.855 us [  6848] | __cxa_atexit();
            [  6848] | main() {
            [  6848] |   a() {
   2.120 us [  6848] |     b();
   3.738 us [  6848] |   } /* a */
   5.209 us [  6848] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -N b a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   2.084 us [  6857] | __monstartup();
   0.790 us [  6857] | __cxa_atexit();
            [  6857] | main() {
   2.260 us [  6857] |   a();
   3.858 us [  6857] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -N a a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   1.754 us [  6866] | __monstartup();
   0.761 us [  6866] | __cxa_atexit();
   2.566 us [  6866] | main();
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

-N FUNC, --notrace=FUNC : Set filter not to trace selected functions and their children functions.

```
minchul@minchul:~/workspace/examples$ uftrace record -N c a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   1.673 us [  6848] | __monstartup();
   0.855 us [  6848] | __cxa_atexit();
            [  6848] | main() {
            [  6848] |   a() {
   2.120 us [  6848] |     b();
   3.738 us [  6848] |   } /* a */
   5.209 us [  6848] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -N b a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   2.084 us [  6857] | __monstartup();
   0.790 us [  6857] | __cxa_atexit();
            [  6857] | main() {
   2.260 us [  6857] |   a();
   3.858 us [  6857] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -N a a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   1.754 us [  6866] | __monstartup();
   0.761 us [  6866] | __cxa_atexit();
   2.566 us [  6866] | main();
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

-N FUNC, --notrace=FUNC : Set filter not to trace selected functions and their children functions.

```
minchul@minchul:~/workspace/examples$ uftrace record -N c a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   1.673 us [  6848] | __monstartup();
   0.855 us [  6848] | __cxa_atexit();
            [  6848] | main() {
            [  6848] |   a() {
   2.120 us [  6848] |     b();
   3.738 us [  6848] |   } /* a */
   5.209 us [  6848] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -N b a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   2.084 us [  6857] | __monstartup();
   0.790 us [  6857] | __cxa_atexit();
            [  6857] | main() {
   2.260 us [  6857] |   a();
   3.858 us [  6857] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -N a a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   1.754 us [  6866] | __monstartup();
   0.761 us [  6866] | __cxa_atexit();
   2.566 us [  6866] | main();
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

-N FUNC, --notrace=FUNC : Set filter not to trace selected functions and their children functions.

```
minchul@minchul:~/workspace/examples$ uftrace record -N c a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   1.673 us [  6848] | __monstartup();
   0.855 us [  6848] | __cxa_atexit();
            [  6848] | main() {
            [  6848] |   a() {
   2.120 us [  6848] |     b();
   3.738 us [  6848] |   } /* a */
   5.209 us [  6848] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -N b a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   2.084 us [  6857] | __monstartup();
   0.790 us [  6857] | __cxa_atexit();
            [  6857] | main() {
   2.260 us [  6857] |   a();
   3.858 us [  6857] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -N a a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
   1.754 us [  6866] | __monstartup();
   0.761 us [  6866] | __cxa_atexit();
   2.566 us [  6866] | main();
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

-C FUNC, --caller-filter=FUNC : Set filter to trace callers of selected functions only.

```
minchul@minchul:~/workspace/examples$ uftrace record -C c a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  6999] | main() {
            [  6999] |   a() {
            [  6999] |     b() {
   0.702 us [  6999] |       c();
   3.020 us [  6999] |     } /* b */
   4.425 us [  6999] |   } /* a */
   5.850 us [  6999] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -C b a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  7010] | main() {
            [  7010] |   a() {
   2.137 us [  7010] |     b();
   4.514 us [  7010] |   } /* a */
   6.083 us [  7010] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -C a a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  7019] | main() {
   3.615 us [  7019] |   a();
   5.893 us [  7019] | } /* main */
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

-C FUNC, --caller-filter=FUNC : Set filter to trace callers of selected functions only.

```
minchul@minchul:~/workspace/examples$ uftrace record -C c a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  6999] | main() {
            [  6999] |   a() {
            [  6999] |     b() {
   0.702 us [  6999] |       c();
   3.020 us [  6999] |     } /* b */
   4.425 us [  6999] |   } /* a */
   5.850 us [  6999] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -C b a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  7010] | main() {
            [  7010] |   a() {
   2.137 us [  7010] |     b();
   4.514 us [  7010] |   } /* a */
   6.083 us [  7010] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -C a a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  7019] | main() {
   3.615 us [  7019] |   a();
   5.893 us [  7019] | } /* main */
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

-C FUNC, --caller-filter=FUNC : Set filter to trace callers of selected functions only.

```
minchul@minchul:~/workspace/examples$ uftrace record -C c a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  6999] | main() {
            [  6999] |   a() {
            [  6999] |     b() {
   0.702 us [  6999] |       c();
   3.020 us [  6999] |     } /* b */
   4.425 us [  6999] |   } /* a */
   5.850 us [  6999] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -C b a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  7010] | main() {
            [  7010] |   a() {
   2.137 us [  7010] |     b();
   4.514 us [  7010] |   } /* a */
   6.083 us [  7010] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -C a a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  7019] | main() {
   3.615 us [  7019] |   a();
   5.893 us [  7019] | } /* main */
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

-C FUNC, --caller-filter=FUNC : Set filter to trace callers of selected functions only.

```
minchul@minchul:~/workspace/examples$ uftrace record -C c a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  6999] | main() {
            [  6999] |   a() {
            [  6999] |     b() {
   0.702 us [  6999] |       c();
   3.020 us [  6999] |     } /* b */
   4.425 us [  6999] |   } /* a */
   5.850 us [  6999] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -C b a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  7010] | main() {
            [  7010] |   a() {
   2.137 us [  7010] |     b();
   4.514 us [  7010] |   } /* a */
   6.083 us [  7010] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace record -C a a.out
minchul@minchul:~/workspace/examples$ uftrace replay
# DURATION     TID     FUNCTION
            [  7019] | main() {
   3.615 us [  7019] |   a();
   5.893 us [  7019] | } /* main */
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

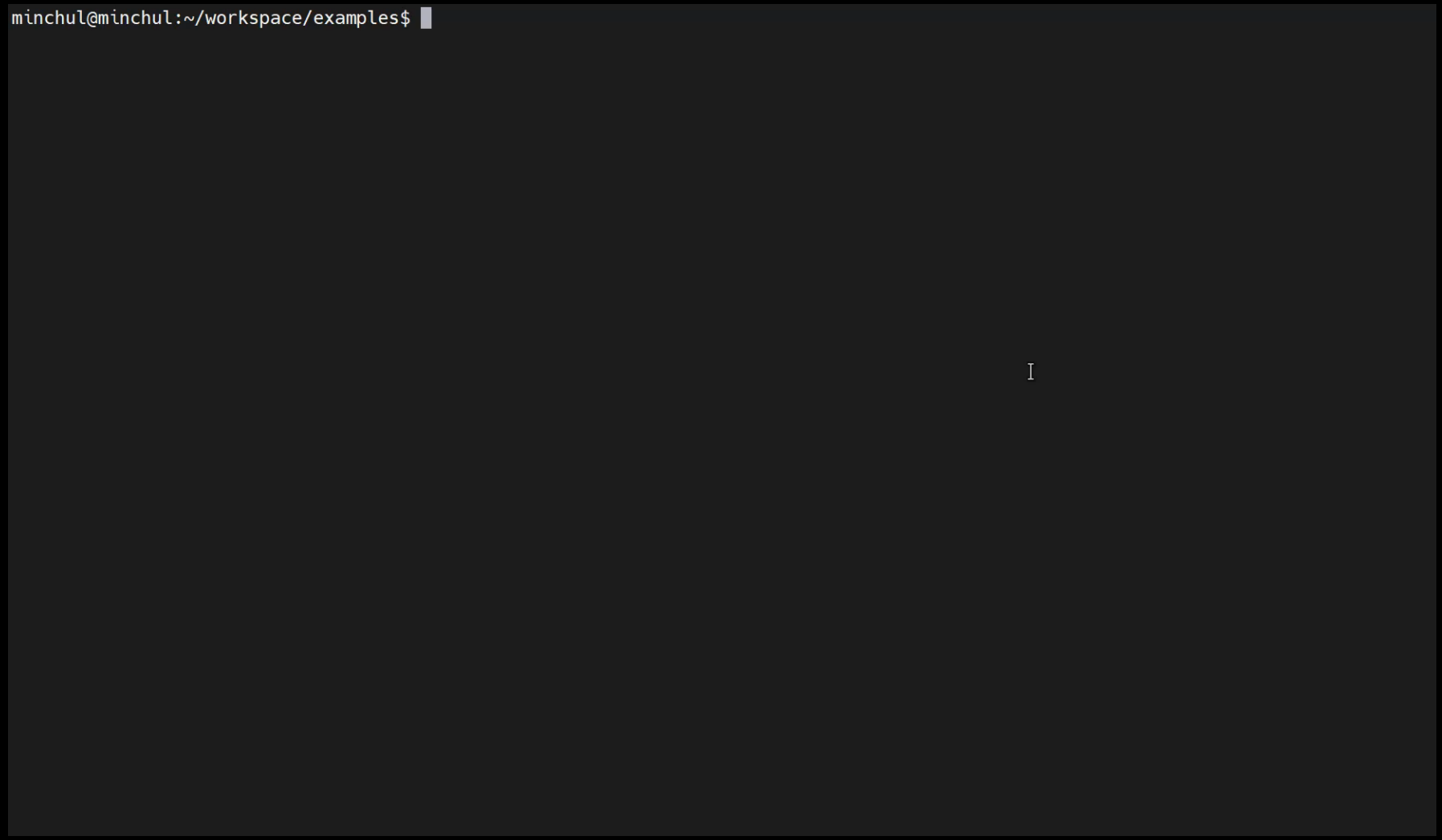
-l, --nest-libcall : Trace function calls between libraries.

See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

-A *SPEC*, --argument=*SPEC* : Record function arguments.

-R *SPEC*, --retval=*SPEC* : Record function return values

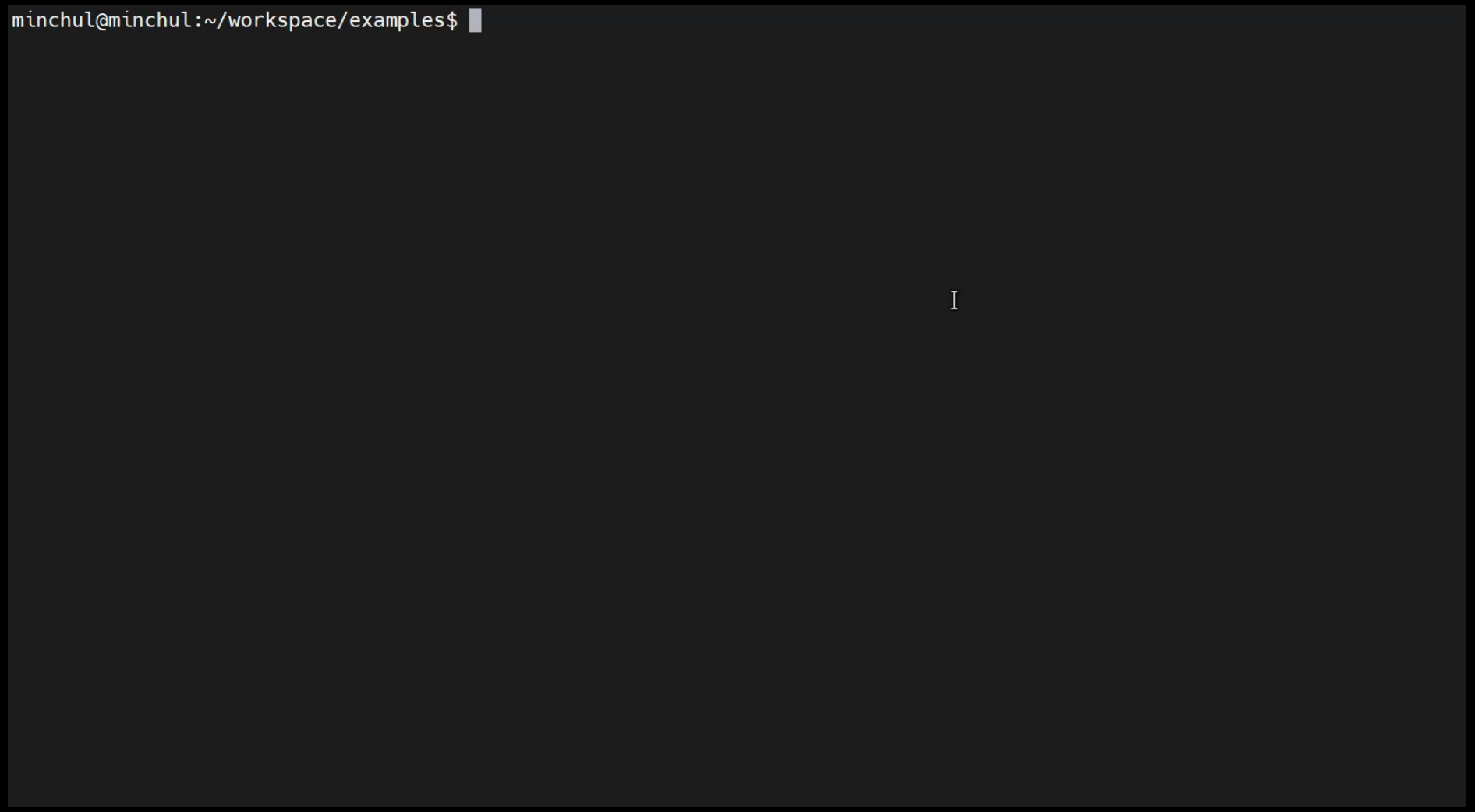


See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – record & replay

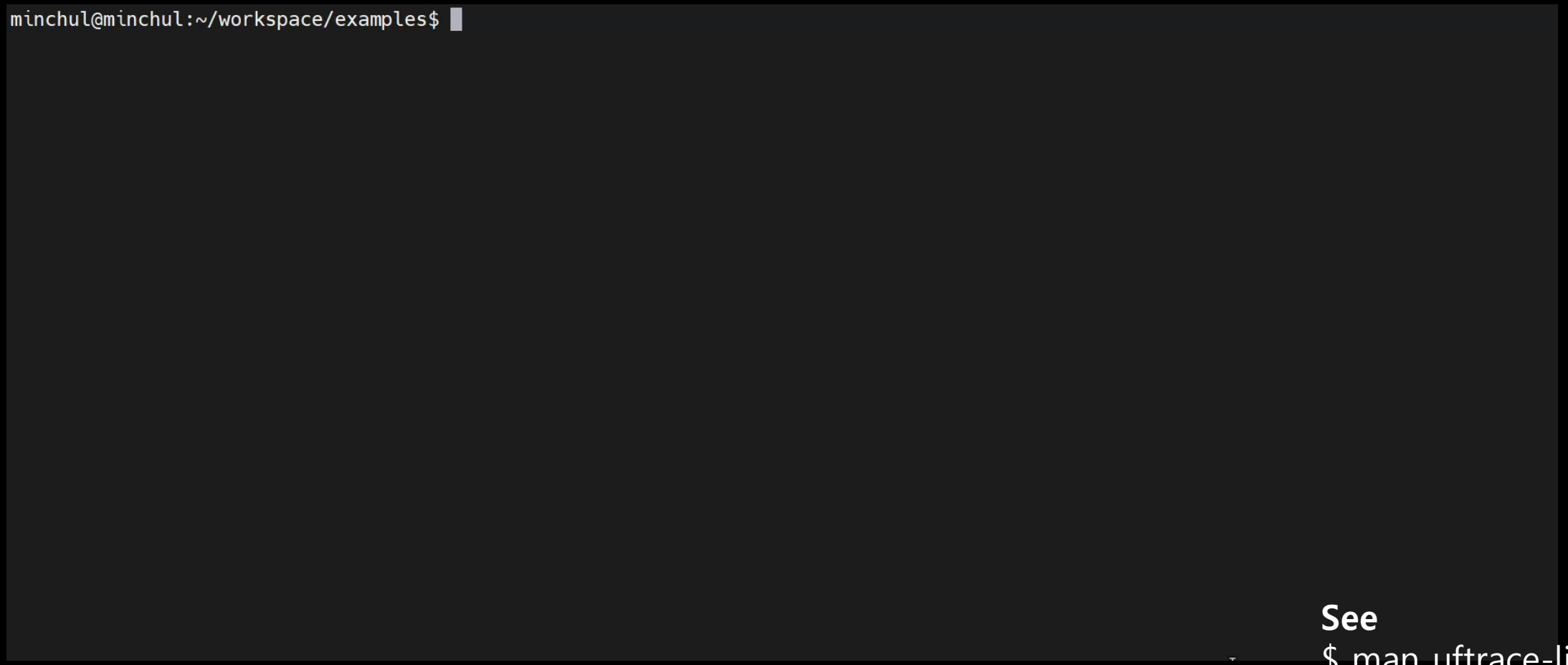
-A *SPEC*, --argument=*SPEC* : Record function arguments.

-R *SPEC*, --retval=*SPEC* : Record function return values



See
$ man uftrace-record
$ man uftrace-replay
for details

Basic usage – live



See
$ man uftrace-live
for details

Basic usage – live

```
minchul@minchul:~/workspace/examples$ gcc -pg foo.c
minchul@minchul:~/workspace/examples$ uftrace -D 2 a.out
# DURATION     TID     FUNCTION
   1.442 us [  9175] | __monstartup();
   0.821 us [  9175] | __cxa_atexit();
            [  9175] | main() {
   0.831 us [  9175] |   a();
   2.482 us [  9175] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace -D 3 a.out
# DURATION     TID     FUNCTION
   1.750 us [  9181] | __monstartup();
   0.782 us [  9181] | __cxa_atexit();
            [  9181] | main() {
            [  9181] |   a() {
   0.852 us [  9181] |     b();
   2.470 us [  9181] |   } /* a */
   3.904 us [  9181] | } /* main */
minchul@minchul:~/workspace/examples$ uftrace -D 4 a.out
# DURATION     TID     FUNCTION
   1.749 us [  9187] | __monstartup();
   0.812 us [  9187] | __cxa_atexit();
            [  9187] | main() {
            [  9187] |   a() {
            [  9187] |     b() {
   0.660 us [  9187] |       c();
   2.238 us [  9187] |     } /* b */
   3.606 us [  9187] |   } /* a */
   5.031 us [  9187] | } /* main */
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-live
for details

Basic usage – live

```
minchul@minchul:~/workspace/examples$ gcc -pg foo.c
minchul@minchul:~/workspace/examples$ uftrace -F a a.out
# DURATION     TID     FUNCTION
            [  9222] | a() {
            [  9222] |   b() {
   0.682 us [  9222] |     c();
   2.886 us [  9222] |   } /* b */
   4.688 us [  9222] | } /* a */
minchul@minchul:~/workspace/examples$ uftrace -F b a.out
# DURATION     TID     FUNCTION
            [  9228] | b() {
   0.793 us [  9228] |   c();
   3.867 us [  9228] | } /* b */
minchul@minchul:~/workspace/examples$ uftrace -F c a.out
# DURATION     TID     FUNCTION
   0.892 us [  9233] | c();
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-live
for details

Basic usage – live

```
minchul@minchul:~/workspace/examples$ g++ -pg new-delete.cpp
minchul@minchul:~/workspace/examples$ uftrace --nest-libcall a.out
# DURATION     TID     FUNCTION
            [  9304] | main() {
            [  9304] |   operator new() {
   1.019 us [  9304] |     malloc();
   4.198 us [  9304] |   } /* operator new */
            [  9304] |   operator delete() {
            [  9304] |     operator delete() {
   1.335 us [  9304] |       free();
   5.285 us [  9304] |     } /* operator delete */
   7.108 us [  9304] |   } /* operator delete */
  14.715 us [  9304] | } /* main */
```

See
$ man uftrace-live
for details

Basic usage – live

```
minchul@minchul:~/workspace/examples$ gcc -pg fib.c
minchul@minchul:~/workspace/examples$ uftrace -A fib@arg1 -R fib@retval a.out
# DURATION     TID     FUNCTION
   1.603 us [  9475] | __monstartup();
   0.796 us [  9475] | __cxa_atexit();
            [  9475] | main() {
            [  9475] |   fib(8) {
            [  9475] |     fib(7) {
            [  9475] |       fib(6) {
            [  9475] |         fib(5) {
            [  9475] |           fib(4) {
            [  9475] |             fib(3) {
   0.698 us [  9475] |               fib(2) = 1;
   0.669 us [  9475] |               fib(1) = 1;
   4.027 us [  9475] |             } = 2; /* fib */
   0.658 us [  9475] |             fib(2) = 1;
   6.793 us [  9475] |           } = 3; /* fib */
            [  9475] |           fib(3) {
   0.649 us [  9475] |             fib(2) = 1;
   0.658 us [  9475] |             fib(1) = 1;
   3.497 us [  9475] |           } = 2; /* fib */
  16.061 us [  9475] |         } = 5; /* fib */
            [  9475] |         fib(4) {
            [  9475] |           fib(3) {
   0.657 us [  9475] |             fib(2) = 1;
   0.651 us [  9475] |             fib(1) = 1;
   3.491 us [  9475] |           } = 2; /* fib */
```

See
$ man uftrace-live
for details

Basic usage – live

-a, --auto-args : Automatically record arguments and return values of known functions.

```
$ gcc -pg -g fib.c
```

See
$ man uftrace-live
for details

Basic usage – live

-a, --auto-args : Automatically record arguments and return values of known functions.

```
$ gcc -pg -g fibo.c
$ uftrace -a a.out 5
fib(5) = 5
# DURATION    TID     FUNCTION
            [31321] | main(2, 0x7ffd62a92a18) {
   1.478 us [31321] |   atoi();
            [31321] |   fib(5) {
            [31321] |     fib(4) {
            [31321] |       fib(3) {
   0.155 us [31321] |         fib(2) = 1;
   0.123 us [31321] |         fib(1) = 1;
   0.883 us [31321] |       } = 2; /* fib */
   0.125 us [31321] |       fib(2) = 1;
   1.483 us [31321] |     } = 3; /* fib */
            [31321] |     fib(3) {
   0.125 us [31321] |       fib(2) = 1;
   0.125 us [31321] |       fib(1) = 1;
   0.774 us [31321] |     } = 2; /* fib */
   2.716 us [31321] |   } = 5; /* fib */
   4.382 us [31321] |   printf("fib(%d) = %d\n") = 11;
   9.456 us [31321] | } = 0; /* main */
```

See
$ man uftrace-live
for details

Basic usage

$ uftrace [COMMAND] [OPTION...] [<program>]

record	Run a program and saves the trace data
replay	Show program execution in the trace data
live	Do record and replay in a row (default)
report	Show performance statistics in the trace data
dump	Show low-level trace data
graph	Show function call graph in the trace data
tui	Show text user interface for graph and report
info	Show system and program info in the trace data
recv	Save the trace data from network
script	Run a script for recorded trace data

Basic usage – report

```
minchul@minchul:~/workspace/examples$ gcc -pg fib.c
minchul@minchul:~/workspace/examples$ uftrace record a.out
minchul@minchul:~/workspace/examples$ uftrace report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   48.781 us    1.302 us           1  main
   47.479 us   47.479 us          41  fib
    1.505 us    1.505 us           1  __monstartup
    0.746 us    0.746 us           1  __cxa_atexit
minchul@minchul:~/workspace/examples$ uftrace -s total report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   48.781 us    1.302 us           1  main
   47.479 us   47.479 us          41  fib
    1.505 us    1.505 us           1  __monstartup
    0.746 us    0.746 us           1  __cxa_atexit
minchul@minchul:~/workspace/examples$ uftrace -s self report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   47.479 us   47.479 us          41  fib
    1.505 us    1.505 us           1  __monstartup
   48.781 us    1.302 us           1  main
    0.746 us    0.746 us           1  __cxa_atexit
minchul@minchul:~/workspace/examples$ uftrace -s call report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   47.479 us   47.479 us          41  fib
    0.746 us    0.746 us           1  __cxa_atexit
    1.505 us    1.505 us           1  __monstartup
   48.781 us    1.302 us           1  main
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-report
for details

Basic usage – report

```
minchul@minchul:~/workspace/examples$ gcc -pg fib.c
minchul@minchul:~/workspace/examples$ uftrace record a.out
minchul@minchul:~/workspace/examples$ uftrace report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   48.781 us    1.302 us           1  main
   47.479 us   47.479 us          41  fib
    1.505 us    1.505 us           1  __monstartup
    0.746 us    0.746 us           1  __cxa_atexit
minchul@minchul:~/workspace/examples$ uftrace -s total report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   48.781 us    1.302 us           1  main
   47.479 us   47.479 us          41  fib
    1.505 us    1.505 us           1  __monstartup
    0.746 us    0.746 us           1  __cxa_atexit
minchul@minchul:~/workspace/examples$ uftrace -s self report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   47.479 us   47.479 us          41  fib
    1.505 us    1.505 us           1  __monstartup
   48.781 us    1.302 us           1  main
    0.746 us    0.746 us           1  __cxa_atexit
minchul@minchul:~/workspace/examples$ uftrace -s call report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   47.479 us   47.479 us          41  fib
    0.746 us    0.746 us           1  __cxa_atexit
    1.505 us    1.505 us           1  __monstartup
   48.781 us    1.302 us           1  main
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-report
for details

Basic usage – report

```
minchul@minchul:~/workspace/examples$ gcc -pg fib.c
minchul@minchul:~/workspace/examples$ uftrace record a.out
minchul@minchul:~/workspace/examples$ uftrace report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   48.781 us    1.302 us           1  main
   47.479 us   47.479 us          41  fib
    1.505 us    1.505 us           1  __monstartup
    0.746 us    0.746 us           1  __cxa_atexit
minchul@minchul:~/workspace/examples$ uftrace -s total report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   48.781 us    1.302 us           1  main
   47.479 us   47.479 us          41  fib
    1.505 us    1.505 us           1  __monstartup
    0.746 us    0.746 us           1  __cxa_atexit
minchul@minchul:~/workspace/examples$ uftrace -s self report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   47.479 us   47.479 us          41  fib
    1.505 us    1.505 us           1  __monstartup
   48.781 us    1.302 us           1  main
    0.746 us    0.746 us           1  __cxa_atexit
minchul@minchul:~/workspace/examples$ uftrace -s call report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   47.479 us   47.479 us          41  fib
    0.746 us    0.746 us           1  __cxa_atexit
    1.505 us    1.505 us           1  __monstartup
   48.781 us    1.302 us           1  main
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-report
for details

Basic usage – report

```
minchul@minchul:~/workspace/examples$ gcc -pg fib.c
minchul@minchul:~/workspace/examples$ uftrace record a.out
minchul@minchul:~/workspace/examples$ uftrace report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   48.781 us    1.302 us           1  main
   47.479 us   47.479 us          41  fib
    1.505 us    1.505 us           1  __monstartup
    0.746 us    0.746 us           1  __cxa_atexit
minchul@minchul:~/workspace/examples$ uftrace -s total report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   48.781 us    1.302 us           1  main
   47.479 us   47.479 us          41  fib
    1.505 us    1.505 us           1  __monstartup
    0.746 us    0.746 us           1  __cxa_atexit
minchul@minchul:~/workspace/examples$ uftrace -s self report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   47.479 us   47.479 us          41  fib
    1.505 us    1.505 us           1  __monstartup
   48.781 us    1.302 us           1  main
    0.746 us    0.746 us           1  __cxa_atexit
minchul@minchul:~/workspace/examples$ uftrace -s call report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   47.479 us   47.479 us          41  fib
    0.746 us    0.746 us           1  __cxa_atexit
    1.505 us    1.505 us           1  __monstartup
   48.781 us    1.302 us           1  main
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-report
for details

Basic usage – report

```
minchul@minchul:~/workspace/examples$ gcc -pg fib.c
minchul@minchul:~/workspace/examples$ uftrace record a.out
minchul@minchul:~/workspace/examples$ uftrace report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   48.781 us    1.302 us           1  main
   47.479 us   47.479 us          41  fib
    1.505 us    1.505 us           1  __monstartup
    0.746 us    0.746 us           1  __cxa_atexit
minchul@minchul:~/workspace/examples$ uftrace -s total report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   48.781 us    1.302 us           1  main
   47.479 us   47.479 us          41  fib
    1.505 us    1.505 us           1  __monstartup
    0.746 us    0.746 us           1  __cxa_atexit
minchul@minchul:~/workspace/examples$ uftrace -s self report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   47.479 us   47.479 us          41  fib
    1.505 us    1.505 us           1  __monstartup
   48.781 us    1.302 us           1  main
    0.746 us    0.746 us           1  __cxa_atexit
minchul@minchul:~/workspace/examples$ uftrace -s call report
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   47.479 us   47.479 us          41  fib
    0.746 us    0.746 us           1  __cxa_atexit
    1.505 us    1.505 us           1  __monstartup
   48.781 us    1.302 us           1  main
minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-report
for details

Basic usage – graph

See
$ man uftrace-graph
for details

Basic usage – graph

```
minchul@minchul:~/workspace/examples$ uftrace graph -f +self
# Function Call Graph for 'a.out' (session: a29dacb5a9480067)
========== FUNCTION CALL GRAPH ==========
# TOTAL TIME   SELF TIME   FUNCTION
   32.273 us             : (1) a.out
   32.273 us    4.546 us : (1) main
    1.520 us    1.520 us :  +-(1) operator new
                         :  |
   10.286 us    1.321 us :  +-(1) std::shared_ptr::shared_ptr
    8.965 us    2.117 us :  | (1) std::__shared_ptr::__shared_ptr
    6.221 us    1.296 us :  |  +-(1) std::__shared_count::__shared_count
    4.925 us    2.192 us :  |  | (1) std::__shared_count::__shared_count
    0.659 us    0.659 us :  |  |  +-(1) operator new
                         :  |  |  |
    2.074 us    1.420 us :  |  |  +-(1) std::_Sp_counted_ptr::_Sp_counted_ptr
    0.654 us    0.654 us :  |  |    (1) std::_Sp_counted_base::_Sp_counted_base
                         :  |  |
    0.627 us    0.627 us :  |  +-(1) std::__shared_ptr::_M_enable_shared_from_this_with
                         :  |
   15.921 us    1.280 us :  +-(1) std::shared_ptr::~shared_ptr
   14.641 us    1.279 us :    (1) std::__shared_ptr::~__shared_ptr
   13.362 us    1.285 us :    (1) std::__shared_count::~__shared_count
   12.077 us    1.973 us :    (1) std::_Sp_counted_base::_M_release
    4.142 us    1.505 us :     +-(1) std::_Sp_counted_ptr::_M_dispose
    2.637 us    2.637 us :     | (1) operator delete
                         :     |
    5.962 us    1.308 us :     +-(1) std::_Sp_counted_ptr::_M_destroy
    4.654 us    1.993 us :       (1) std::_Sp_counted_ptr::~_Sp_counted_ptr
    2.003 us    1.394 us :        +-(1) std::_Sp_counted_ptr::~_Sp_counted_ptr
    0.609 us    0.609 us :        | (1) std::_Sp_counted_base::~_Sp_counted_base
                         :        |
    0.658 us    0.658 us :        +-(1) operator delete

minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-graph
for details

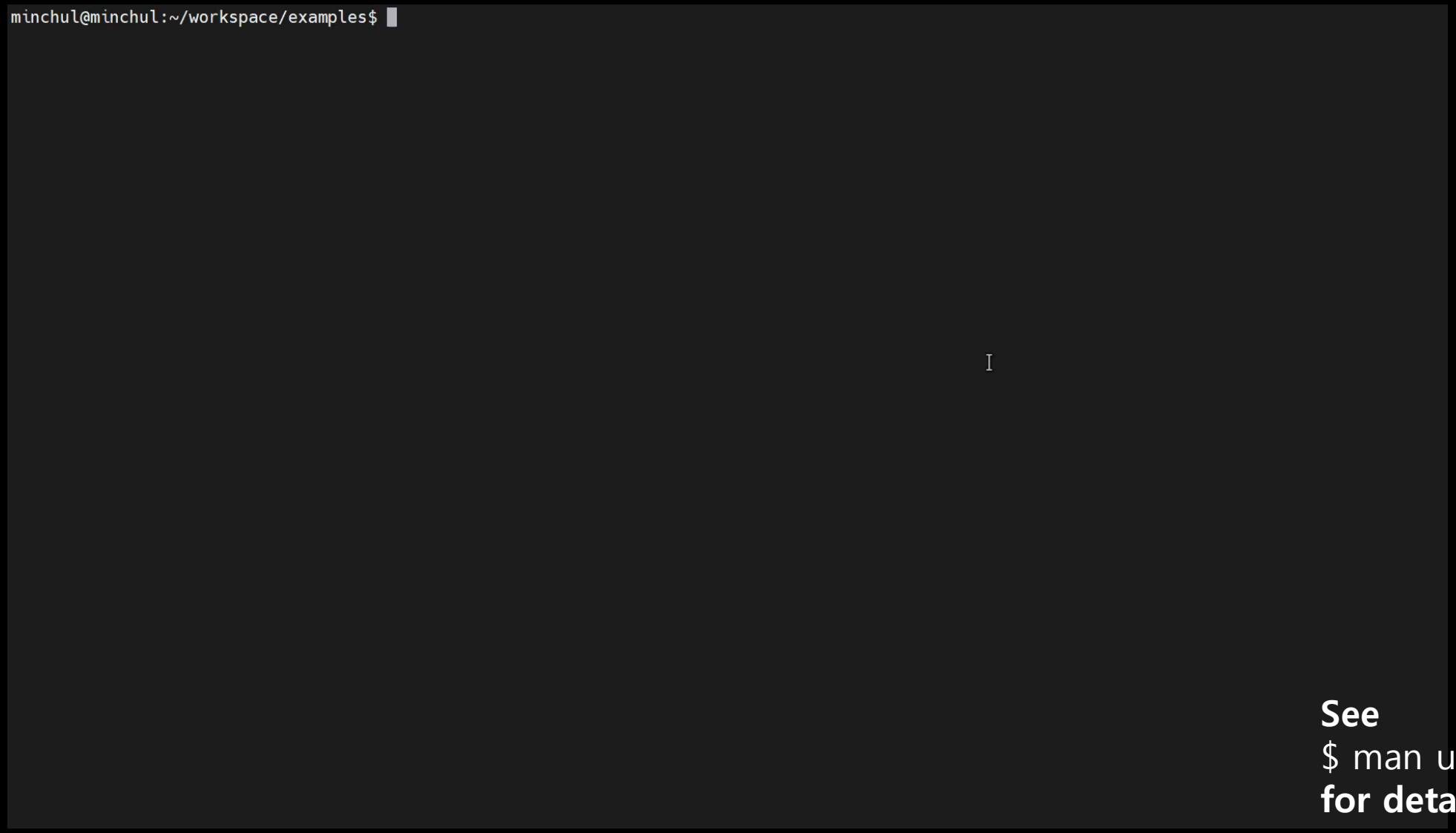
Basic usage – graph

```
minchul@minchul:~/workspace/examples$ uftrace graph -f +self,addr
# Function Call Graph for 'a.out' (session: a29dacb5a9480067)
========== FUNCTION CALL GRAPH ==========
# TOTAL TIME   SELF TIME     ADDRESS     FUNCTION
   32.273 us              55e44b6ed2bb : (1) a.out
   32.273 us    4.546 us  55e44b6ed2bb : (1) main
    1.520 us    1.520 us  55e44b6ed0f0 :  +-(1) operator new
                                       :  |
   10.286 us    1.321 us  55e44b6ed370 :  +-(1) std::shared_ptr::shared_ptr
    8.965 us    2.117 us  55e44b6ed3d4 :  | (1) std::__shared_ptr::__shared_ptr
    6.221 us    1.296 us  55e44b6ed55e :  |  +-(1) std::__shared_count::__shared_count
    4.925 us    2.192 us  55e44b6ed5e5 :  |  | (1) std::__shared_count::__shared_count
    0.659 us    0.659 us  55e44b6ed0f0 :  |  |  +-(1) operator new
                                       :  |  |  |
    2.074 us    1.420 us  55e44b6ed6d2 :  |  |  +-(1) std::_Sp_counted_ptr::_Sp_counted_ptr
    0.654 us    0.654 us  55e44b6ed716 :  |  |    (1) std::_Sp_counted_base::_Sp_counted_base
                                       :  |  |
    0.627 us    0.627 us  55e44b6ed58e :  |  +-(1) std::__shared_ptr::_M_enable_shared_from_this_with
                                       :  |
   15.921 us    1.280 us  55e44b6ed34a :  +-(1) std::shared_ptr::~shared_ptr
   14.641 us    1.279 us  55e44b6ed320 :    (1) std::__shared_ptr::~__shared_ptr
   13.362 us    1.285 us  55e44b6ed3a0 :    (1) std::__shared_count::~__shared_count
   12.077 us    1.973 us  55e44b6ed426 :    (1) std::_Sp_counted_base::_M_release
    4.142 us    1.505 us  55e44b6ed7be :     +-(1) std::_Sp_counted_ptr::_M_dispose
    2.637 us    2.637 us  55e44b6ed110 :     | (1) operator delete
                                       :     |
    5.962 us    1.308 us  55e44b6ed7f2 :     +-(1) std::_Sp_counted_ptr::_M_destroy
    4.654 us    1.993 us  55e44b6ed788 :       (1) std::_Sp_counted_ptr::~_Sp_counted_ptr
    2.003 us    1.394 us  55e44b6ed754 :        +-(1) std::_Sp_counted_ptr::~_Sp_counted_ptr
    0.609 us    0.609 us  55e44b6ed674 :        | (1) std::_Sp_counted_base::~_Sp_counted_base
                                       :        |
    0.658 us    0.658 us  55e44b6ed110 :        +-(1) operator delete

minchul@minchul:~/workspace/examples$
```

See
$ man uftrace-graph
for details

Basic usage – tui



See
$ man uftrace-tui
for details

Basic usage – dump

```
minchul@minchul:~/workspace/examples$ g++ -pg shared_ptr.cpp
minchul@minchul:~/workspace/examples$ sudo uftrace -k record a.out
minchul@minchul:~/workspace/examples$ uftrace dump --chrome > shared_ptr.json
minchul@minchul:~/workspace/examples$ ls
a.out  shared_ptr.cpp   shared_ptr.json    uftrace.data
```

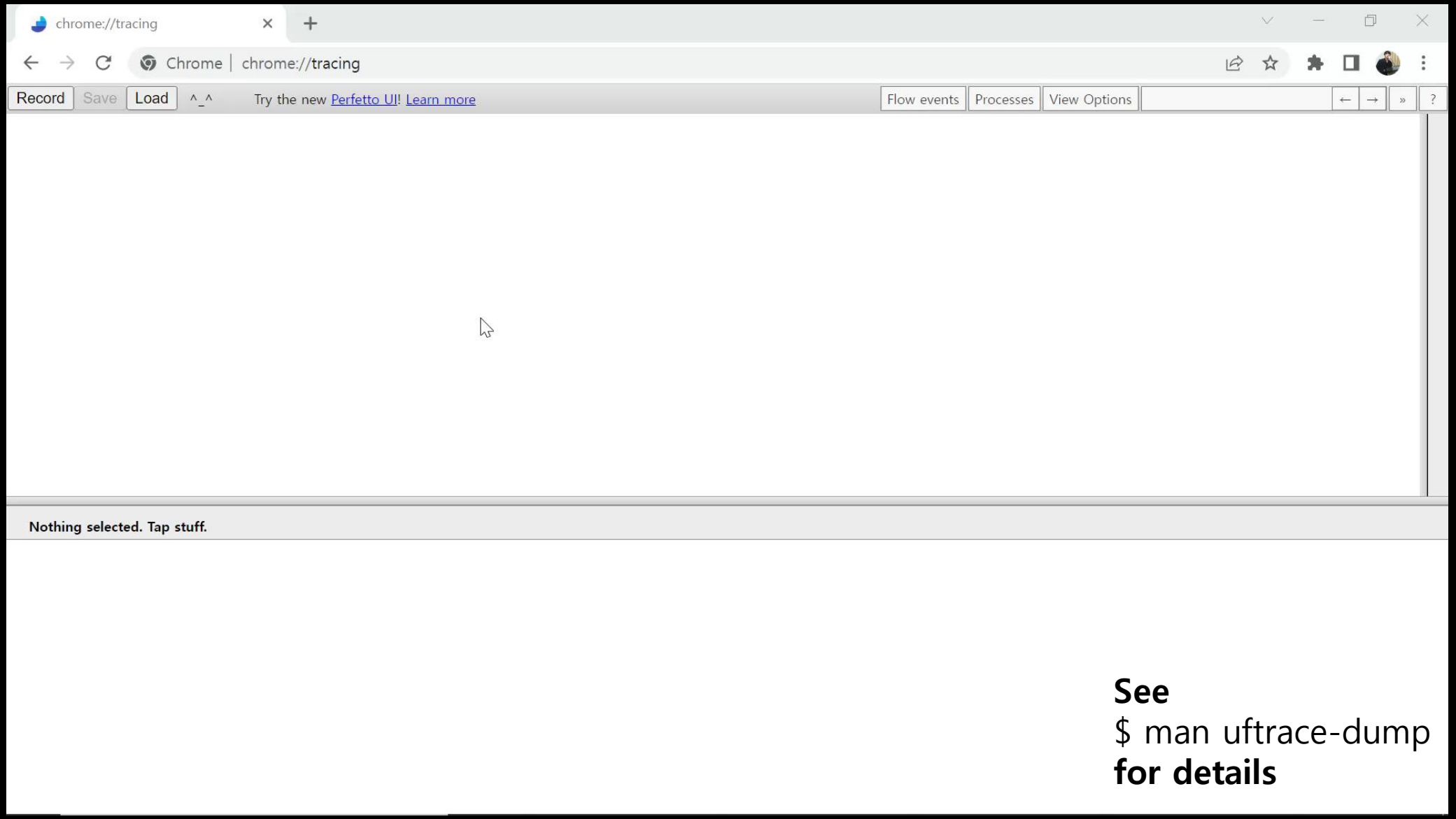
See
$ man uftrace-dump
for details

Basic usage – dump

```
minchul@minchul:~/workspace/examples$ g++ -pg shared_ptr.cpp
minchul@minchul:~/workspace/examples$ sudo uftrace -k record a.out
minchul@minchul:~/workspace/examples$ uftrace dump --chrome > shared_ptr.json
minchul@minchul:~/workspace/examples$ ls
a.out  shared_ptr.cpp   shared_ptr.json    uftrace.data
```

See
$ man uftrace-dump
for details

Basic usage – dump



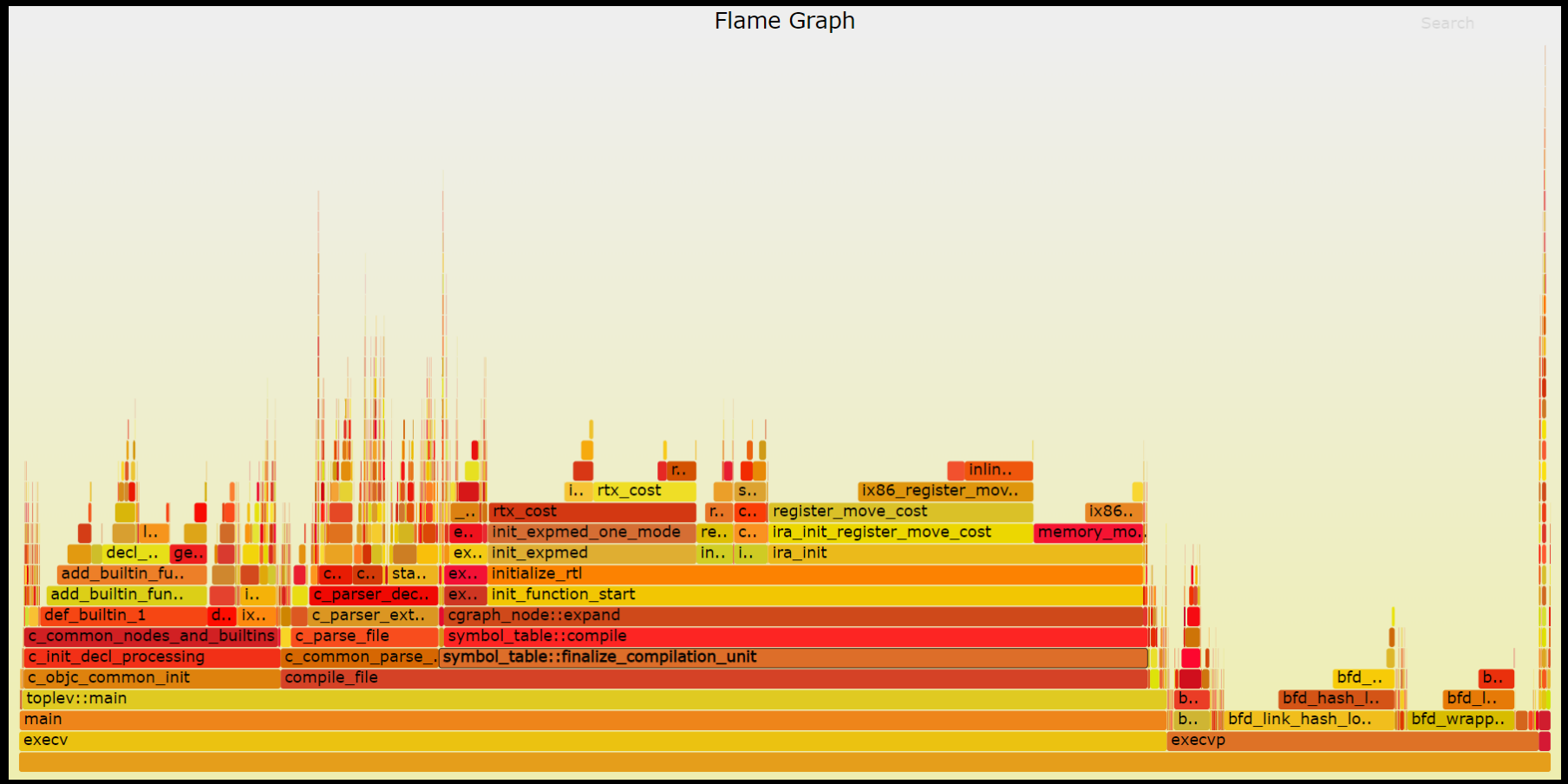
See
$ man uftrace-dump
for details

Basic usage – dump

```
$ uftrace dump --flame-graph | flamegraph.pl > out.svg
```

See
$ man uftrace-dump
for details

Basic usage – dump



https://uftrace.github.io/dump/gcc.svg

Tracing open sources-1 : git

How commit hashes are generated?

(what function generates commit hashes?)

Tracing open sources-1 : git

Download the git source code

```
$ wget https://github.com/git/git/archive/v2.23.0.tar.gz
$ tar -zxf v2.23.0.tar.gz
$ cd git-2.23.0/
```

Tracing open sources-1 : git

Install dependencies for compiling the Git binaries

```
$ sudo apt-get install dh-autoreconf libcurl4-gnutls-dev \
libexpat1-dev gettext libz-dev libssl-dev install-info
```

Tracing open sources-1 : git

Building Git from source using CMake

```
$ autoreconf
$ CFLAGS='-pg -g' CXXFLAGS='-pg -g' ./configure
```

Execute make

```
$ make -j4 all
```

Tracing open sources-1 : git

Check the generated Git binary

```
$ ./git --version
git version 2.23.0

$ nm ./git | grep mcount
                 U mcount@@GLIBC_2.2.5
```

Tracing open sources-1 : git

Initialize local repository & create, add file

```
$ ./git init
Initialized empty Git repository in /root/workspace/git-2.23.0/.git/
$ touch test
$ echo "a" >> test
$ ./git add test
```

Tracing open sources-1 : git

Make a first commit

```
$ ./git commit -m "first commit"
[master (root-commit) 528cafa] first commit
 Committer: root <root@ip-172-31-41-133.ap-northeast-2.compute.internal>
Your name and email address were configured automatically based
on your username and hostname. Please check that they are accurate.
You can suppress this message by setting them explicitly. Run the
following command and follow the instructions in your editor to edit
your configuration file:

    git config --global --edit

After doing this, you may fix the identity used for this commit with:

    git commit --amend --reset-author

 1 file changed, 1 insertion(+)
 create mode 100644 test
$
```

Tracing open sources-1 : git

Check commit hash

```
$ ./git log
commit 528cafa6b4860ec6ba44e1ff1a606b2a855a509e (HEAD -> master)
Author: root <root@ip-172-31-41-133.ap-northeast-2.compute.internal>
Date:   Sat Jun 25 17:29:28 2022 +0000

    first commit
$
```

```
$ echo "b" >> test && ./git add test
$ ./git commit -m "second commit"
[master 5c8fc28] second commit
 Committer: root <root@ip-172-31-41-133.ap-northeast-2.compute.internal>
Your name and email address were configured automatically based
on your username and hostname. Please check that they are accurate.
You can suppress this message by setting them explicitly. Run the
following command and follow the instructions in your editor to edit
your configuration file:

    git config --global --edit

After doing this, you may fix the identity used for this commit with:

    git commit --amend --reset-author

 1 file changed, 1 insertion(+)
$ echo "c" >> test && ./git add test
$ ./git commit -m "third commit"
[master 3c3f0a5] third commit
 Committer: root <root@ip-172-31-41-133.ap-northeast-2.compute.internal>
Your name and email address were configured automatically based
on your username and hostname. Please check that they are accurate.
You can suppress this message by setting them explicitly. Run the
following command and follow the instructions in your editor to edit
your configuration file:

    git config --global --edit

After doing this, you may fix the identity used for this commit with:

    git commit --amend --reset-author

 1 file changed, 1 insertion(+)
$
```

```
$ echo "b" >> test && ./git add test
$ ./git commit -m "second commit"
[master 5c8fc28] second commit
 Committer: root <root@ip-172-31-41-133.ap-northeast-2.compute.internal>
Your name and email address were configured automatically based
on your username and hostname. Please check that they are accurate.
You can suppress this message by setting them explicitly. Run the
following command and follow the instructions in your editor to edit
your configuration file:

    git config --global --edit

After doing this, you may fix the identity used for this commit with:

    git commit --amend --reset-author

 1 file changed, 1 insertion(+)
$ echo "c" >> test && ./git add test
$ ./git commit -m "third commit"
[master 3c3f0a5] third commit
 Committer: root <root@ip-172-31-41-133.ap-northeast-2.compute.internal>
Your name and email address were configured automatically based
on your username and hostname. Please check that they are accurate.
You can suppress this message by setting them explicitly. Run the
following command and follow the instructions in your editor to edit
your configuration file:

    git config --global --edit

After doing this, you may fix the identity used for this commit with:

    git commit --amend --reset-author

 1 file changed, 1 insertion(+)
$
```

Tracing open sources-1 : git

Check commit hashes

```
$ ./git log
commit 3c3f0a54d3452154a0bbb8abee137177d60947ef (HEAD -> master)
Author: root <root@ip-172-31-41-133.ap-northeast-2.compute.internal>
Date:   Sat Jun 25 17:32:18 2022 +0000

    third commit

commit 5c8fc289fbdc91c379feeb925cfb18cd06e9131e
Author: root <root@ip-172-31-41-133.ap-northeast-2.compute.internal>
Date:   Sat Jun 25 17:32:05 2022 +0000

    second commit

commit 528cafa6b4860ec6ba44e1ff1a606b2a855a509e
Author: root <root@ip-172-31-41-133.ap-northeast-2.compute.internal>
Date:   Sat Jun 25 17:29:28 2022 +0000

    first commit
$
```

Tracing open sources-1 : git

Test and check the generated Git binary

```
$ uftrace record -a ./git log
commit 3c3f0a54d3452154a0bbb8abee137177d60947ef (HEAD -> master)
Author: root <root@ip-172-31-41-133.ap-northeast-2.compute.internal>
Date:   Sat Jun 25 17:32:18 2022 +0000

    third commit

commit 5c8fc289fbdc91c379feeb925cfb18cd06e9131e
Author: root <root@ip-172-31-41-133.ap-northeast-2.compute.internal>
Date:   Sat Jun 25 17:32:05 2022 +0000

    second commit

commit 528cafa6b4860ec6ba44e1ff1a606b2a855a509e
Author: root <root@ip-172-31-41-133.ap-northeast-2.compute.internal>
Date:   Sat Jun 25 17:29:28 2022 +0000

    first commit
$
```

```
# DURATION     TID     FUNCTION
            [104590] | main(2, 0x7ffe18cb1348) {
            [104590] |   trace2_initialize_clock() {
            [104590] |     tr2tls_start_process_clock() {
            [104590] |       getnanotime() {
            [104590] |         gettimeofday_nanos() {
   2.710 us [104590] |           gettimeofday();
   6.398 us [104590] |         } = 0x16fbed8c180465d8; /* gettimeofday_nanos */
            [104590] |         highres_nanos() {
   1.408 us [104590] |           clock_gettime(CLOCK_MONOTONIC, 0x7ffe18cb11a0) = 0;
   3.413 us [104590] |         } = 0x70e903de4a2d; /* highres_nanos */
  19.561 us [104590] |       } = 0x16fbed8c180465d8; /* getnanotime */
  22.790 us [104590] |     } /* tr2tls_start_process_clock */
  40.636 us [104590] |   } /* trace2_initialize_clock */
            [104590] |   sanitize_stdfds() {
 121.019 us [104590] |     open64("/dev/null", O_RDWR) = 4;
   2.209 us [104590] |     close(4) = 0;
 126.635 us [104590] |   } /* sanitize_stdfds */
            [104590] |   restore_sigpipe_to_default() {
   0.737 us [104590] |     sigemptyset(0x7ffe18cb1170) = 0;
   0.800 us [104590] |     sigaddset(0x7ffe18cb1170, SIGPIPE) = 0;
   1.654 us [104590] |     sigprocmask(SIG_UNBLOCK, 0x7ffe18cb1170, 0) = 0;
   1.874 us [104590] |     signal(SIGPIPE, 0) = 0;
  10.260 us [104590] |   } /* restore_sigpipe_to_default */
   0.815 us [104590] |   git_resolve_executable_dir("./git");
            [104590] |   trace2_initialize_fl("common-main.c", 42) {
            [104590] |     tr2_sysenv_load() {
            [104590] |       read_very_early_config(&tr2_sysenv_cb, 0) {
            [104590] |         config_with_options(&tr2_sysenv_cb, 0, 0, 0x7ffe18cb1180) {
            [104590] |           do_git_config_sequence(0x7ffe18cb1180, &git_config_include, 0x7ffe18cb1130) {
            [104590] |             xdg_config_home("config") {
   5.215 us [104590] |               getenv("XDG_CONFIG_HOME") = "NULL";
   0.919 us [104590] |               getenv("HOME") = "/root";
            [104590] |               mkpathdup("%s/.config/git/%s") {
            [104590] |                 strbuf_vaddf(0x7ffe18cb0f70, "%s/.config/git/%s", 0x7ffe18cb0f90) {
   0.873 us [104590] |                   strbuf_avail(0x7ffe18cb0f70) = 0;
            [104590] |                   strbuf_grow(0x7ffe18cb0f70, 64) {
   0.748 us [104590] |                     st_mult(1, 65) = 65;
            [104590] |                     xrealloc(0, 65) {
            [104590] |                       memory_limit_check(65, 0) {
            [104590] |                         git_env_ulong("GIT_ALLOC_LIMIT", 0) {
:
```

```
# DURATION     TID     FUNCTION
            [104590] | main(2, 0x7ffe18cb1348) {
            [104590] |   trace2_initialize_clock() {
            [104590] |     tr2tls_start_process_clock() {
            [104590] |       getnanotime() {
            [104590] |         gettimeofday_nanos() {
   2.710 us [104590] |           gettimeofday();
   6.398 us [104590] |         } = 0x16fbed8c180465d8; /* gettimeofday_nanos */
            [104590] |         highres_nanos() {
   1.408 us [104590] |           clock_gettime(CLOCK_MONOTONIC, 0x7ffe18cb11a0) = 0;
   3.413 us [104590] |         } = 0x70e903de4a2d; /* highres_nanos */
  19.561 us [104590] |       } = 0x16fbed8c180465d8; /* getnanotime */
  22.790 us [104590] |     } /* tr2tls_start_process_clock */
  40.636 us [104590] |   } /* trace2_initialize_clock */
            [104590] |   sanitize_stdfds() {
 121.019 us [104590] |     open64("/dev/null", O_RDWR) = 4;
   2.209 us [104590] |     close(4) = 0;
 126.635 us [104590] |   } /* sanitize_stdfds */
            [104590] |   restore_sigpipe_to_default() {
   0.737 us [104590] |     sigemptyset(0x7ffe18cb1170) = 0;
   0.800 us [104590] |     sigaddset(0x7ffe18cb1170, SIGPIPE) = 0;
   1.654 us [104590] |     sigprocmask(SIG_UNBLOCK, 0x7ffe18cb1170, 0) = 0;
   1.874 us [104590] |     signal(SIGPIPE, 0) = 0;
  10.260 us [104590] |   } /* restore_sigpipe_to_default */
   0.815 us [104590] |   git_resolve_executable_dir("./git");
            [104590] |   trace2_initialize_fl("common-main.c", 42) {
            [104590] |     tr2_sysenv_load() {
            [104590] |       read_very_early_config(&tr2_sysenv_cb, 0) {
            [104590] |         config_with_options(&tr2_sysenv_cb, 0, 0, 0x7ffe18cb1180) {
            [104590] |           do_git_config_sequence(0x7ffe18cb1180, &git_config_include, 0x7ffe18cb1130) {
            [104590] |             xdg_config_home("config") {
   5.215 us [104590] |               getenv("XDG_CONFIG_HOME") = "NULL";
   0.919 us [104590] |               getenv("HOME") = "/root";
            [104590] |               mkpathdup("%s/.config/git/%s") {
            [104590] |                 strbuf_vaddf(0x7ffe18cb0f70, "%s/.config/git/%s", 0x7ffe18cb0f90) {
   0.873 us [104590] |                   strbuf_avail(0x7ffe18cb0f70) = 0;
            [104590] |                   strbuf_grow(0x7ffe18cb0f70, 64) {
   0.748 us [104590] |                     st_mult(1, 65) = 65;
            [104590] |                     xrealloc(0, 65) {
            [104590] |                       memory_limit_check(65, 0) {
            [104590] |                         git_env_ulong("GIT_ALLOC_LIMIT", 0) {
/} = "3c3f0a54d3452154a0bbb8abee137177d60947ef"
```

```
  3.376 us [104590] |                  } = "3c3f0a54d3452154a0bbb8abee137177d60947ef"; /* oid_to_hex_r */
  5.340 us [104590] |                } = 40; /* repo_find_unique_abbrev_r */
  7.309 us [104590] |              } = "3c3f0a54d3452154a0bbb8abee137177d60947ef"; /* repo_find_unique_abbrev */
  0.866 us [104590] |              fputs("3c3f0a54d3452154a0bbb8abee137177d60947ef", &_IO_2_1_stdout_) = 1;
           [104590] |              diff_get_color(-1, DIFF_RESET) {
  0.709 us [104590] |                want_color_fd(1, -1) = 1;
  2.306 us [104590] |              } = ""; /* diff_get_color */
  0.798 us [104590] |              fputs("", &_IO_2_1_stdout_) = 1;
           [104590] |              show_decorations(0x7ffe18cb0510, 0x5638bd8dd390) {
           [104590] |                format_decorations_extended(0x7ffe18cb00b0, 0x5638bd8dd390, -1, " (", ", ", ")") {
           [104590] |                  diff_get_color(-1, DIFF_COMMIT) {
  0.662 us [104590] |                    want_color_fd(1, -1) = 1;
  2.251 us [104590] |                  } = ""; /* diff_get_color */
           [104590] |                  decorate_get_color(-1, DECORATION_NONE) {
  0.671 us [104590] |                    want_color_fd(1, -1) = 1;
  2.419 us [104590] |                  } = ""; /* decorate_get_color */
           [104590] |                  get_name_decoration(0x5638bd8dd390) {
           [104590] |                    lookup_decoration(&name_decoration, 0x5638bd8dd390) {
           [104590] |                      hash_obj(0x5638bd8dd390, 1500) {
  0.720 us [104590] |                        oidhash(0x5638bd8dd398) = 0x540a3f3c;
  2.369 us [104590] |                      } = 1192; /* hash_obj */
  4.219 us [104590] |                    } = 0x5638bd8dbbc0; /* lookup_decoration */
  6.530 us [104590] |                  } = 0x5638bd8dbbc0; /* get_name_decoration */
           [104590] |                  current_pointed_by_HEAD(0x5638bd8dbbc0) {
           [104590] |                    resolve_ref_unsafe("HEAD", 0, 0, 0x7ffe18cafffc) {
  0.699 us [104590] |                      get_main_ref_store(0x5638bbb376c0) = 0x5638bd8bf8f0;
           [104590] |                      refs_resolve_ref_unsafe(0x5638bd8bf8f0, "HEAD", 0, 0, 0x7ffe18cafffc) {
           [104590] |                        check_refname_format("HEAD", 1) {
           [104590] |                          check_or_sanitize_refname("HEAD", 1, 0) {
  0.838 us [104590] |                            check_refname_component("HEAD", 0x7ffe18cafee4, 0) = 4;
  2.731 us [104590] |                          } = 0; /* check_or_sanitize_refname */
  4.400 us [104590] |                        } = 0; /* check_refname_format */
           [104590] |                        refs_read_raw_ref(0x5638bd8bf8f0, "HEAD", 0x7ffe18caff70, &sb_refname.2, 0x7ffe18caff68) {
           [104590] |                          files_read_raw_ref(0x5638bd8bf8f0, "HEAD", 0x7ffe18caff70, &sb_refname.2, 0x7ffe18caff68) {
  0.976 us [104590] |                            files_downcast(0x5638bd8bf8f0, 1, "read_raw_ref") = 0x5638bd8bf8f0;
  0.703 us [104590] |                            strbuf_setlen(0x7ffe18cafe20, 0);
           [104590] |                            files_ref_path(0x5638bd8bf8f0, 0x7ffe18cafe20, "HEAD") {
           [104590] |                              ref_type("HEAD") {
  0.764 us [104590] |                                is_per_worktree_ref("HEAD") = 1;
  2.421 us [104590] |                              } = REF_TYPE_PER_WORKTREE; /* ref_type */
           [104590] |                              strbuf_addf(0x7ffe18cafe20, "%s/%s") {
:
```

Tracing open sources-1 : git

Replay recorded data

```
$ uftrace replay -F oid_to_hex_r -D 1
# DURATION     TID     FUNCTION
   3.376 us [104590] | oid_to_hex_r("", 0x5638bd8dd398) = "3c3f0a54d3452154a0bbb8abee137177d60947ef";
   2.797 us [104590] | oid_to_hex_r("", 0x5638bd8dd3e8) = "5c8fc289fbdc91c379feeb925cfb18cd06e9131e";
   2.710 us [104590] | oid_to_hex_r("", 0x5638bd8dd438) = "528cafa6b4860ec6ba44e1ff1a606b2a855a509e";
```

Tracing open sources-1 : git

oid_to_hex_r()?

```
$ grep -n oid_to_hex_r *.c
diff.c:4095:    oid_to_hex_r(temp->hex, oid);
diff.c:4143:                            oid_to_hex_r(temp->hex, &null_oid);
diff.c:4145:                            oid_to_hex_r(temp->hex, &one->oid);
hex.c:98:char *oid_to_hex_r(char *buffer, const struct object_id *oid)
sequencer.c:4502:                       oid_to_hex_r(p, oid);
sha1-file.c:163:        return oid_to_hex_r(buf, the_hash_algo->empty_tree);
sha1-file.c:169:        return oid_to_hex_r(buf, the_hash_algo->empty_blob);
sha1-name.c:703:        oid_to_hex_r(hex, oid);
upload-pack.c:412:                              oid_to_hex_r(last_hex, &oid);
$
```

Tracing open sources-1 : git

oid_to_hex_r()?

```
 98 char *oid_to_hex_r(char *buffer, const struct object_id *oid)
 99 {
100         return hash_to_hex_algop_r(buffer, oid->hash, the_hash_algo);
101 }
```

Tracing open sources-1 : git

hash_to_hex_algo_r?

```
minchul@minchul:~/workspace/git-2.23.0$ uftrace replay -F hash_to_hex_algop_r -D 1
# DURATION     TID     FUNCTION
   1.170 us [104590] | hash_to_hex_algop_r("", 0x5638bd8dd398, &hash_algos) = "3c3f0a54d3452154a0bbb8abee137177d60947ef";
   0.896 us [104590] | hash_to_hex_algop_r("", 0x5638bd8dd3e8, &hash_algos) = "5c8fc289fbdc91c379feeb925cfb18cd06e9131e";
   0.880 us [104590] | hash_to_hex_algop_r("", 0x5638bd8dd438, &hash_algos) = "528cafa6b4860ec6ba44e1ff1a606b2a855a509e";
```

Tracing open sources-1 : git

hash_to_hex_algo_r?

```
$ grep -n hash_to_hex_algop_r *.c *.h
hex.c:76:char *hash_to_hex_algop_r(char *buffer, const unsigned char *hash,
hex.c:95:       return hash_to_hex_algop_r(buffer, sha1, &hash_algos[GIT_HASH_SHA1]);
hex.c:100:      return hash_to_hex_algop_r(buffer, oid->hash, the_hash_algo);
hex.c:108:      return hash_to_hex_algop_r(hexbuffer[bufno], hash, algop);
cache.h:1419:char *hash_to_hex_algop_r(char *buffer, const unsigned char *hash, const struct git_hash_algo *);
$
```

Tracing open sources-1 : git

Test and check the generated Git binary

```
76 char *hash_to_hex_algop_r(char *buffer, const unsigned char *hash,
77                           const struct git_hash_algo *algop)
78 {
79         static const char hex[] = "0123456789abcdef";
80         char *buf = buffer;
81         int i;
82
83         for (i = 0; i < algop->rawsz; i++) {
84                 unsigned int val = *hash++;
85                 *buf++ = hex[val >> 4];
86                 *buf++ = hex[val & 0xf];
87         }
88         *buf = '\0';
89
90         return buffer;
91 }
```

```
 TOTAL TIME : FUNCTION
  52.655 ms : (1) git
  52.552 ms :   ├─(1) main
  29.366 us :   │   ├─(1) trace2_initialize_clock
  23.608 us :   │   │ (1) tr2tls_start_process_clock
  20.441 us :   │   │ (1) getnanotime
   6.386 us :   │   │   ├─(1) gettimeofday_nanos
   2.372 us :   │   │   │ (1) gettimeofday
            :   │   │   │
   3.717 us :   │   │   └─(1) highres_nanos
   1.596 us :   │   │     (1) clock_gettime
            :   │   │
 131.552 us :   │   ├─(1) sanitize_stdfds
 126.051 us :   │   │   ├─(1) open64
            :   │   │   │
   1.905 us :   │   │   └─(1) close
            :   │   │
  10.857 us :   │   ├─(1) restore_sigpipe_to_default
   0.772 us :   │   │   ├─(1) sigemptyset
            :   │   │   │
   0.925 us :   │   │   ├─(1) sigaddset
            :   │   │   │
   1.888 us :   │   │   ├─(1) sigprocmask
            :   │   │   │
   1.870 us :   │   │   └─(1) signal
            :   │   │
   0.839 us :   │   ├─(1) git_resolve_executable_dir
            :   │   │
 214.065 us :   │   ├─(1) trace2_initialize_fl
 179.320 us :   │   │   ├─(1) tr2_sysenv_load
 172.709 us :   │   │   │ (1) read_very_early_config
 170.945 us :   │   │   │ (1) config_with_options
 168.684 us :   │   │   │ (1) do_git_config_sequence
  64.807 us :   │   │   │   ├─(1) xdg_config_home
   6.641 us :   │   │   │   │   ├─(2) getenv
            :   │   │   │   │   │
  53.433 us :   │   │   │   │   └─(1) mkpathdup
  35.760 us :   │   │   │   │     ├─(1) strbuf_vaddf
   1.642 us :   │   │   │   │     │   ├─(2) strbuf_avail
            :   │   │   │   │     │   │
  23.158 us :   │   │   │   │     │   ├─(1) strbuf_grow
   0.761 us :   │   │   │   │     │   │   ├─(1) st_mult
            :   │   │   │   │     │   │   │
uftrace graph: session 1dcc8031f442e29b (/root/workspace/git-2.23.0/git)                0%
```

```
  TOTAL TIME : FUNCTION
   52.655 ms : (1) git
   52.552 ms :   ├─(1) main
   29.366 us :   │ ├─(1) trace2_initialize_clock
   23.608 us :   │ │ (1) tr2tls_start_process_clock
   20.441 us :   │ │ (1) getnanotime
    6.386 us :   │ │   ├─(1) gettimeofday_nanos
    2.372 us :   │ │   │ (1) gettimeofday
             :   │ │   │
    3.717 us :   │ │   └─(1) highres_nanos
    1.596 us :   │ │     (1) clock_gettime
             :   │ │
  131.552 us :   │ ├─(1) sanitize_stdfds
  126.051 us :   │ │   ├─(1) open64
             :   │ │   │
    1.905 us :   │ │   └─(1) close
             :   │ │
   10.857 us :   │ ├─(1) restore_sigpipe_to_default
    0.772 us :   │ │   ├─(1) sigemptyset
             :   │ │   │
    0.925 us :   │ │   ├─(1) sigaddset
             :   │ │   │
    1.888 us :   │ │   ├─(1) sigprocmask
             :   │ │   │
    1.870 us :   │ │   └─(1) signal
             :   │ │
    0.839 us :   │ ├─(1) git_resolve_executable_dir
             :   │ │
  214.065 us :   │ ├─(1) trace2_initialize_fl
  179.320 us :   │ │   ├─(1) tr2_sysenv_load
  172.709 us :   │ │   │ (1) read_very_early_config
  170.945 us :   │ │   │ (1) config_with_options
  168.684 us :   │ │   │ (1) do_git_config_sequence
   64.807 us :   │ │   │   ├─(1) xdg_config_home
    6.641 us :   │ │   │   │ ├─(2) getenv
             :   │ │   │   │ │
   53.433 us :   │ │   │   │ └─(1) mkpathdup
   35.760 us :   │ │   │   │   ├─(1) strbuf_vaddf
    1.642 us :   │ │   │   │   │ ├─(2) strbuf_avail
             :   │ │   │   │   │ │
   23.158 us :   │ │   │   │   │ ├─(1) strbuf_grow
    0.761 us :   │ │   │   │   │ │ ├─(1) st_mult
             :   │ │   │   │   │ │ │
uftrace graph: searching "hash_to_algop_r"  (0 match, use '<' and '>' keys to navigate)                    0%
```

```
Search function:
 (press ESC to exit)


  hash_to_hex_algop_r
```

```
  TOTAL TIME : FUNCTION
    1.004 us :                                  (1) buffer_slab_at_peek
             :
   25.045 us :                                 (1) set_commit_buffer
   23.383 us :                                   (1) buffer_slab_at
   21.768 us :                                   (1) buffer_slab_at_peek
    1.001 us :                                     (1) st_mult
             :
    3.775 us :                                     (1) xrealloc
    0.660 us :                                       (1) memory_limit_check
             :
    0.756 us :                                       (1) realloc
             :
   12.232 us :                                     (1) xcalloc
    0.672 us :                                       (1) memory_limit_check
             :
    9.089 us :                                       (1) calloc
             :
    4.704 us :                                 (1) get_lock_file_fd
    2.532 us :                                   (1) get_tempfile_fd
    0.711 us :                                   (1) is_tempfile_active
             :
    4.710 us :                                 (1) oid_to_hex
    2.979 us :                                   (1) hash_to_hex_algop
    1.123 us :                                   (1) hash_to_hex_algop_r
             :
   21.572 us :                                 (2) write_in_full
   18.359 us :                                   (2) xwrite
   14.683 us :                                   (2) write
             :
    8.763 us :                                 (1) close_ref_gently
    7.238 us :                                   (1) close_lock_file_gently
    5.686 us :                                   (1) close_tempfile_gently
    0.660 us :                                     (1) is_tempfile_active
             :
    2.475 us :                                       (1) close
             :
    0.820 us :                             (1) string_list_clear
             :
  994.894 us :                         (1) files_transaction_finish
    0.906 us :                           (1) files_downcast
             :
  820.920 us :                           (2) files_log_ref_write
uftrace graph: searching "hash_to_hex_algop_r"  (4 match, use '<' and '>' keys to navigate)                66%
```

```
# Function Call Graph for 'git' (session: 1dcc8031f442e29b)
========== FUNCTION CALL GRAPH ==========
# TOTAL TIME   FUNCTION
   52.552 ms : (1) git
   52.552 ms : (1) main
   29.366 us :  +-(1) trace2_initialize_clock
   23.608 us :  | (1) tr2tls_start_process_clock
   20.441 us :  | (1) getnanotime
    6.386 us :  |  +-(1) gettimeofday_nanos
    2.372 us :  |  | (1) gettimeofday
             :  |  |
    3.717 us :  |  +-(1) highres_nanos
    1.596 us :  |    (1) clock_gettime
             :  |
  131.552 us :  +-(1) sanitize_stdfds
  126.051 us :  |  +-(1) open64
             :  |  |
    1.905 us :  |  +-(1) close
             :  |
   10.857 us :  +-(1) restore_sigpipe_to_default
    0.772 us :  |  +-(1) sigemptyset
             :  |  |
    0.925 us :  |  +-(1) sigaddset
             :  |  |
    1.888 us :  |  +-(1) sigprocmask
             :  |  |
    1.870 us :  |  +-(1) signal
             :  |
    0.839 us :  +-(1) git_resolve_executable_dir
             :  |
  214.065 us :  +-(1) trace2_initialize_fl
  179.320 us :  |  +-(1) tr2_sysenv_load
  172.709 us :  |  | (1) read_very_early_config
  170.945 us :  |  | (1) config_with_options
  168.684 us :  |  | (1) do_git_config_sequence
   64.807 us :  |  |  +-(1) xdg_config_home
    6.641 us :  |  |  |  +-(2) getenv
             :  |  |  |  |
   53.433 us :  |  |  |  +-(1) mkpathdup
   35.760 us :  |  |  |     +-(1) strbuf_vaddf
    1.642 us :  |  |  |     |  +-(2) strbuf_avail
             :  |  |  |     |  |
   23.158 us :  |  |  |     |  +-(1) strbuf_grow
:
```

```
$ uftrace graph oid_to_hex_r
# Function Call Graph for 'oid_to_hex_r' (session: ff47bd198e7c80da)
============== BACKTRACE ==============
 backtrace #0: hit 3, time   8.883 us
   [0] main (0x5638bb842132)
   [1] cmd_main (0x5638bb76b280)
   [2] run_argv (0x5638bb76aed6)
   [3] handle_builtin (0x5638bb76ab32)
   [4] run_builtin (0x5638bb76a632)
   [5] cmd_log (0x5638bb7c76b6)
   [6] cmd_log_walk (0x5638bb7c63aa)
   [7] log_tree_commit (0x5638bb8ecd94)
   [8] show_log (0x5638bb8ebaf7)
   [9] repo_find_unique_abbrev (0x5638bb9a1294)
   [10] repo_find_unique_abbrev_r (0x5638bb9a10a4)
   [11] oid_to_hex_r (0x5638bb8dca9b)

========== FUNCTION CALL GRAPH ==========
# TOTAL TIME   FUNCTION
    8.883 us : (3) oid_to_hex_r
    2.946 us : (3) hash_to_hex_algop_r
```

Advanced usage – full dynamic tracing

```
$ ./configure
capstone: [ on  ]
```

Advanced usage – full dynamic tracing

```
$ cat foobar.c
void bar() {

}

void foo() {
  bar();
}

int main() {
  foo();
  bar();
}
```

```
$ gcc -pg foobar.c
<bar>:
  call <mcount@plt>
  ret


<foo>:
  call <mcount@plt>
  call <bar>
  ret


<main>:
  call <mcount@plt>
  call <foo>
  call <bar>
  ret
```

Advanced usage – full dynamic tracing

```
$ gcc foobar.c
<bar>:

  ret


<foo>:

  call <bar>
  ret


<main>:

  call <foo>
  call <bar>
  ret
```

Advanced usage – full dynamic tracing

```
$ gcc foobar.c
<bar>:

  ret


<foo>:

  call <bar>
  ret


<main>:
  call <mcount@plt>
  call <foo>
  call <bar>
  ret
```

```
$ uftrace -P main a.out
# DURATION     TID     FUNCTION
   1.420 us [ 14766] | main();
```

-P FUNC/--patch=FUNC Patch FUNC dynamically

Advanced usage – full dynamic tracing

```
$ gcc foobar.c
<bar>:
  call <mcount@plt>
  ret


<foo>:
  call <mcount@plt>
  call <bar>
  ret


<main>:

  call <foo>
  call <bar>
  ret
```

```
$ uftrace -P foo -P bar a.out
# DURATION     TID     FUNCTION
            [ 14813] | foo() {
   0.507 us [ 14813] |   bar();
   4.130 us [ 14813] | } /* foo */
   0.240 us [ 14813] | bar();
```

-P FUNC/--patch=FUNC Patch FUNC dynamically

Advanced usage – full dynamic tracing

```
$ gcc foobar.c
<bar>:
  call <mcount@plt>
  ret


<foo>:
  call <mcount@plt>
  call <bar>
  ret


<main>:
  call <mcount@plt>
  call <foo>
  call <bar>
  ret
```

```
$ uftrace -P . a.out
# DURATION     TID     FUNCTION
            [ 14830] | main() {
            [ 14830] |   foo() {
   0.303 us [ 14830] |     bar();
   2.433 us [ 14830] |   } /* foo */
   0.176 us [ 14830] |   bar();
   4.917 us [ 14830] | } /* main */
```

-P FUNC/--patch=FUNC Patch FUNC dynamically

Tracing open sources-2 : nmap

How nmap displays scanned result?

Tracing open sources-2 : nmap

Build nmap from source

```
$ git clone https://github.com/nmap/nmap.git
$ cd nmap
$ ./configure
$ make
```

Tracing open sources-2 : nmap

Test and check the generated nmap binary

```
$ ./nmap nmap.org
Starting Nmap 7.92SVN ( https://nmap.org ) at 2022-06-25 20:31 KST
Nmap scan report for nmap.org (45.33.49.119)
Host is up (0.19s latency).
Other addresses for nmap.org (not scanned): 2600:3c01:e000:3e6::6d4e:7061
rDNS record for 45.33.49.119: ack.nmap.org
Not shown: 993 filtered tcp ports (no-response)
PORT      STATE  SERVICE
22/tcp    open   ssh
25/tcp    open   smtp
70/tcp    closed gopher
80/tcp    open   http
113/tcp   closed ident
443/tcp   open   https
31337/tcp closed Elite

Nmap done: 1 IP address (1 host up) scanned in 13.48 seconds
```

Tracing open sources-2 : nmap

Of course, you can just build with –pg option @Makefile

```
...
# With GCC, add extra security checks to source code.
# http://gcc.gnu.org/ml/gcc-patches/2004-09/msg02055.html
# Level 1 only makes changes that don't affect "conforming" programs,
# while level 2 enforces additional restrictions.
DEFS += -D_FORTIFY_SOURCE=2
# For mtrace debugging -- see MTRACE define in main.cc for instructions
# Should only be enabled during debugging and not in any real release.
# DEFS += -DMTRACE=1
CXXFLAGS = -g -O2 -Wall -fno-strict-aliasing $(DBGFLAGS) $(CCOPT)
CPPFLAGS = -I$(top_srcdir)/liblinear -I$(top_srcdir)/liblua -I$(top_srcdir)/libdnet-stripped/include
-I$(top_srcdir)/libssh2/include  -I$(top_srcdir)/libpcap -I$(top_srcdir)/nbase -I$(top_srcdir)/nsock/include $(DEFS)
CFLAGS = -g -O2 -Wall $(DBGFLAGS) $(CCOPT)
STATIC =
LDFLAGS = -Wl,-E  -Lnbase -Lnsock/src/ $(DBGFLAGS) $(STATIC)
LIBS =  -lnsock -lnbase -lpcre $(LIBPCAPDIR)/libpcap.a $(LIBSSH2_LIBS) $(OPENSSL_LIBS) $(ZLIB_LIBS)
libnetutil/libnetutil.a $(top_srcdir)/libdnet-stripped/src/.libs/libdnet.a $(top_srcdir)/liblua/liblua.a
$(top_srcdir)/liblinear/liblinear.a -ldl
OPENSSL_LIBS = -lssl -lcrypto
LIBSSH2_LIBS = libssh2/lib/libssh2.a
ZLIB_LIBS = -lz
# LIBS =  -lefence -ldl
# LIBS =  -lrmalloc -ldl
INSTALL = /usr/bin/install -c
# MAKEDEPEND = @MAKEDEPEND@
export RPMTDIR=$(HOME)/rpm
# Whether the user wants to install translated man pages. If "yes", then
# all translated man pages are installed, unless a subset is specified
# with the LINGUAS environment variable.
USE_NLS = yes
...
```

Tracing open sources-2 : nmap

Of course, you can just build with –pg option @Makefile

```
...
# With GCC, add extra security checks to source code.
# http://gcc.gnu.org/ml/gcc-patches/2004-09/msg02055.html
# Level 1 only makes changes that don't affect "conforming" programs,
# while level 2 enforces additional restrictions.
DEFS += -D_FORTIFY_SOURCE=2
# For mtrace debugging -- see MTRACE define in main.cc for instructions
# Should only be enabled during debugging and not in any real release.
# DEFS += -DMTRACE=1
CXXFLAGS = -pg -g -O2 -Wall -fno-strict-aliasing $(DBGFLAGS) $(CCOPT)
CPPFLAGS = -I$(top_srcdir)/liblinear -I$(top_srcdir)/liblua -I$(top_srcdir)/libdnet-stripped/include
-I$(top_srcdir)/libssh2/include  -I$(top_srcdir)/libpcap -I$(top_srcdir)/nbase -I$(top_srcdir)/nsock/include $(DEFS)
CFLAGS = -pg -g -O2 -Wall $(DBGFLAGS) $(CCOPT)
STATIC =
LDFLAGS = -Wl,-E  -Lnbase -Lnsock/src/ $(DBGFLAGS) $(STATIC)
LIBS =  -lnsock -lnbase -lpcre $(LIBPCAPDIR)/libpcap.a $(LIBSSH2_LIBS) $(OPENSSL_LIBS) $(ZLIB_LIBS)
libnetutil/libnetutil.a $(top_srcdir)/libdnet-stripped/src/.libs/libdnet.a $(top_srcdir)/liblua/liblua.a
$(top_srcdir)/liblinear/liblinear.a -ldl
OPENSSL_LIBS = -lssl -lcrypto
LIBSSH2_LIBS = libssh2/lib/libssh2.a
ZLIB_LIBS = -lz
# LIBS =  -lefence -ldl
# LIBS =  -lrmalloc -ldl
INSTALL = /usr/bin/install -c
# MAKEDEPEND = @MAKEDEPEND@
export RPMTDIR=$(HOME)/rpm
# Whether the user wants to install translated man pages. If "yes", then
# all translated man pages are installed, unless a subset is specified
# with the LINGUAS environment variable.
USE_NLS = yes
...
```

Tracing open sources-2 : nmap

Record with uftrace (full dynamic tracing)

```
$ uftrace record -P. -a ./nmap nmap.org
Starting Nmap 7.92SVN ( https://nmap.org ) at 2022-06-25 20:54 KST
Nmap scan report for nmap.org (45.33.49.119)
Host is up (0.20s latency).
Other addresses for nmap.org (not scanned): 2600:3c01:e000:3e6::6d4e:7061
rDNS record for 45.33.49.119: ack.nmap.org
Not shown: 993 filtered tcp ports (no-response)
PORT      STATE  SERVICE
22/tcp    open   ssh
25/tcp    open   smtp
70/tcp    closed gopher
80/tcp    open   http
113/tcp   closed ident
443/tcp   open   https
31337/tcp closed Elite
```

Tracing open sources-2 : nmap

Record with uftrace (full dynamic tracing)

```
$ uftrace record -P. -a ./nmap nmap.org
Starting Nmap 7.92SVN ( https://nmap.org ) at 2022-06-25 20:54 KST
Nmap scan report for nmap.org (45.33.49.119)
Host is up (0.20s latency).
Other addresses for nmap.org (not scanned): 2600:3c01:e000:3e6::6d4e:7061
rDNS record for 45.33.49.119: ack.nmap.org
Not shown: 993 filtered tcp ports (no-response)
PORT      STATE  SERVICE
22/tcp    open   ssh
25/tcp    open   smtp
70/tcp    closed gopher
80/tcp    open   http
113/tcp   closed ident
443/tcp   open   https
31337/tcp closed Elite
```

Tracing open sources-2 : nmap

Record with uftrace (full dynamic tracing)

```
$ uftrace record -P. -a ./nmap nmap.org
Starting Nmap 7.92SVN ( https://nmap.org ) at 2022-06-25 20:54 KST
Nmap scan report for nmap.org (45.33.49.119)
Host is up (0.20s latency).
Other addresses for nmap.org (not scanned): 2600:3c01:e000:3e6::6d4e:7061
rDNS record for 45.33.49.119: ack.nmap.org
Not shown: 993 filtered tcp ports (no-response)
PORT      STATE  SERVICE
22/tcp    open   ssh
25/tcp    open   smtp
70/tcp    closed gopher
80/tcp    open   http
113/tcp   closed ident
443/tcp   open   https
31337/tcp closed Elite
```

Tracing open sources-2 : nmap

Replay recorded data

```
$ uftrace replay -F main
# DURATION     TID     FUNCTION
            [  7831] | main(2, 0x7ffe07a8f0b8) {
   0.246 us [  7831] |   getenv("NMAP_ARGS") = "NULL";
            [  7831] |   nmap_main(2, 0x7ffe07a8f0b8) {
   0.779 us [  7831] |     uname();
   0.321 us [  7831] |     strstr("5.4.0-113-generic", "Microsoft") = "NULL";
  10.995 us [  7831] |     tzset();
   0.086 us [  7831] |     time();
            [  7831] |     n_localtime(0x7ffe07a8e090, 0x563224f85960) {
   7.174 us [  7831] |       localtime();
   7.828 us [  7831] |     } = 0; /* n_localtime */
   0.117 us [  7831] |     operator new(800) = 0x56322625d4a0;
            [  7831] |     parse_options(2, 0x7ffe07a8f0b8) {
...
```

Tracing open sources-2 : nmap

Search desired function (argument, return value...)

```
$ uftrace replay
...
            [  7831] |      NmapOutputTable::addItem(0x5632269b0f60, 7, 0, 1, "31337/tcp", -1) {
   0.566 us [  7831] |        strlen("31337/tcp") = 9;
            [  7831] |        safe_malloc(10) {
   0.810 us [  7831] |          malloc(10) = 0x5632269b06d0;
   2.417 us [  7831] |        } = 0x5632269b06d0; /* safe_malloc */
   0.405 us [  7831] |        memcpy(0x5632269b06d0, 0x7ffe07a8d8c0, 9);
   6.966 us [  7831] |      } /* NmapOutputTable::addItem */
...
```

Tracing open sources-2 : nmap

```
$ uftrace replay -F NmapOutputTable::addItem -D 1
# DURATION     TID     FUNCTION
   1.430 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 0, 0, 0, "PORT", 4);
   0.722 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 0, 1, 0, "STATE", 5);
   0.701 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 0, 2, 0, "SERVICE", 7);
   6.973 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 1, 0, 1, "22/tcp", -1);
   2.219 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 1, 1, 0, "open", -1);
   4.774 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 1, 2, 1, "ssh", -1);
   5.333 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 2, 0, 1, "25/tcp", -1);
   1.841 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 2, 1, 0, "open", -1);
   4.320 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 2, 2, 1, "smtp", -1);
   5.096 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 3, 0, 1, "70/tcp", -1);
   2.095 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 3, 1, 0, "closed", -1);
   4.250 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 3, 2, 1, "gopher", -1);
   4.776 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 4, 0, 1, "80/tcp", -1);
   1.953 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 4, 1, 0, "open", -1);
   4.509 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 4, 2, 1, "http", -1);
   5.799 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 5, 0, 1, "113/tcp", -1);
   1.871 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 5, 1, 0, "closed", -1);
   4.597 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 5, 2, 1, "ident", -1);
   9.355 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 6, 0, 1, "443/tcp", -1);
   2.681 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 6, 1, 0, "open", -1);
   6.133 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 6, 2, 1, "https", -1);
   6.966 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 7, 0, 1, "31337/tcp", -1);
   1.757 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 7, 1, 0, "closed", -1);
   4.588 us [  7831] | NmapOutputTable::addItem(0x5632269b0f60, 7, 2, 1, "Elite", -1);
```

Tracing open sources-2 : nmap

Check report from uftrace

```
$ uftrace report
  Total time   Self time      Calls  Function
  ==========  ==========  ==========  ====================
   27.649  s    2.697 us           1  main
   27.649  s   80.134 us           1  nmap_main
   27.365  s  253.875 ms           2  ultra_scan
   26.551  s   26.551  s         846  linux:schedule
   26.425  s    4.035 ms         716  readip_pcap
   26.421  s   11.825 ms         716  read_reply_pcap
   26.405  s    8.114 ms         716  pcap_select
   26.395  s   26.915 ms         716  select
   25.765  s    5.060 ms         715  get_pcap_result
  766.287 ms    7.825 us           3  nexthost
  766.280 ms   26.968 us           3  refresh_hostbatch
  669.427 ms   21.854 us           1  get_ping_pcap_result
  267.541 ms    8.875 us           1  apply_delayed_options
  267.264 ms    8.892 ms           1  gettoppts
  250.161 ms   59.757 ms          19  nmap_services_init
  198.107 ms   24.746 ms        2011  sendIPScanProbe
```

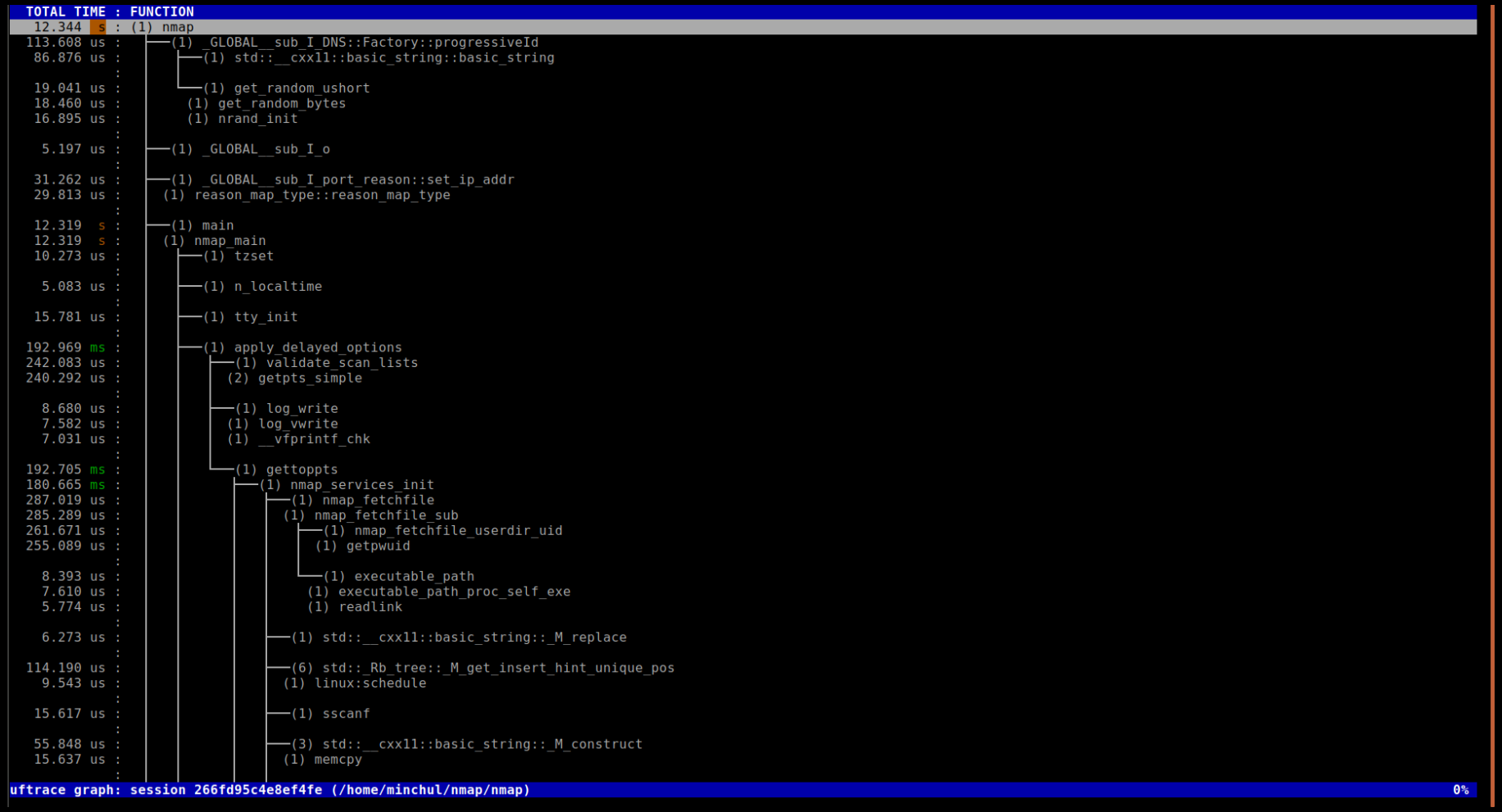
Tracing open sources-2 : nmap

Check report from uftrace (self time)

```
$ uftrace report -s self
  Total time   Self time       Calls  Function
  ==========  ==========  ==========  ====================
   26.551  s   26.551  s         846  linux:schedule
   27.365  s  253.875 ms           2  ultra_scan
  174.341 ms  174.295 ms      464857  HostScanStats::probeExpireTime
   61.468 ms   60.997 ms        2011  sendto
  250.161 ms   59.757 ms          19  nmap_services_init
   96.120 ms   58.213 ms       27432  std::__cxx11::list::merge
   30.900 ms   30.900 ms      326737  service_node_ratio_compare
   26.395  s   26.915 ms         716  select
  198.107 ms   24.746 ms        2011  sendIPScanProbe
   27.435 ms   18.317 ms        3772  HostScanStats::sendOK
   19.555 ms   15.352 ms       30817  std::_Rb_tree::_M_erase
   14.968 ms   13.793 ms       54868  std::_Rb_tree::_M_lower_bound
```

Tracing open sources-2 : nmap

Analyze with TUI



Tracing open sources-2 : nmap

Analyze with call graph (specific function)

```
$ uftrace graph ultra_scan
# Function Call Graph for 'ultra_scan' (session: 1326b21ac8aea8fd)
============== BACKTRACE ==============
 backtrace #0: hit 1, time  26.601  s
   [0] main (0x563224a63975)
   [1] nmap_main (0x563224a91845)
   [2] ultra_scan (0x563224abf315)

 backtrace #1: hit 1, time 763.270 ms
   [0] main (0x563224a63975)
   [1] nmap_main (0x563224a91845)
   [2] nexthost (0x563224ada9d5)
   [3] refresh_hostbatch (0x563224ad9db5)
   [4] ultra_scan (0x563224abf315)

========== FUNCTION CALL GRAPH ==========
# TOTAL TIME   FUNCTION
   27.365  s : (2) ultra_scan
    1.897 us :  +-(2) PacketRateMeter::PacketRateMeter
             :  |
  126.691 us :  +-(2) UltraScanInfo::Init
    0.368 us :  |  +-(2) gettimeofday
```

insights from uftrace

- debug & analyze binaries faster
- Integrated analysis for user-level & kerenel & library function
- with no source code modification
- with less overhead

For more info

https://github.com/namhyung/uftrace/

Thank You

tegongkang@gmail.com

2022. 7. 4.