

uftrace 를 활용한 C++ 프로그램의 실행시간 동작 방식의 이해

C++ Korea 4회 세미나

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uftrace 소개

- C/C++ 프로그램에 대한 함수 호출 관계를 추적하는 도구
 - Creator: 김남형 <namhyung@kernel.org>
 - 리눅스 커널 개발자
 - 리눅스 내부 **perf** 성능 프로파일링 도구의 코드 리뷰어
 - linux/tools/perf/*
 - Linux perf 와 유사한 명령어 구조
 - 함수 실행 시 record 한 후 replay 와 같은 명령으로 분석

uftrace 소개

- uftrace 가 분석할 수 있는 것들
 - C/C++ 사용자(user-space) 함수
 - 컴파일 시 **-pg** 나 **-finstrument-functions** 옵션 필요
 - 또는 **-finstrument-functions-after-inlining** (clang only)
 - 또는 **-fxray-instrument** (clang only)
 - 라이브러리 함수 (library functions)
 - 리눅스 커널(kernel-space) 내부 함수
 - 시스템 이벤트들

\$

```
$ cat hello.c
```

```
$ cat hello.c
```

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

```
int main()
```

```
{
```

```
    printf("Hello, C++ Korea!\n");
```

```
    return 0;
```

```
}
```

\$


```
$ gcc hello.c
```

```
$ gcc hello.c
```

```
$
```

```
$ gcc hello.c
```

```
$ ./a.out
```

```
$ gcc hello.c
```

```
$ ./a.out
```

```
Hello, C++ Korea!
```

```
$ gcc hello.c
```

```
$ ./a.out
```

```
Hello, {C++ Korea!
```

이 프로그램은 내부에서
어떻게 실행이 되었을까?

```
$ gcc hello.c
```

```
$ gcc -pg hello.c
```

```
$ gcc -pg hello.c
```

```
$ ./a.out
```



```
$ gcc -pg hello.c
```

```
$ uftrace ./a.out
```

```
$ gcc -pg hello.c
```

```
$ uftrace ./a.out  
Hello, C++ Korea!
```

```
$ gcc -pg hello.c
```

```
$ uftrace ./a.out
```

```
Hello, C++ Korea!
```

#	DURATION	TID	FUNCTION
	1.447 us	[120218]	__monstartup();
	0.997 us	[120218]	__cxa_atexit();
		[120218]	main() {
	7.214 us	[120218]	printf();
	8.246 us	[120218]	} /* main */

```
$ ./a.out
```

```
$ ./a.out
```

```
a.out
```

```
$ ./a.out
```

```
a.out
```

```
printf("Hello, C++ Korea!")
```



```
$ uftrace ./a.out
```

```
$ uftrace ./a.out
```

```
LD_PRELOAD=libmcount.so a.out
```



```
$ uftrace ./a.out
```

```
LD_PRELOAD=libmcount.so a.out
```



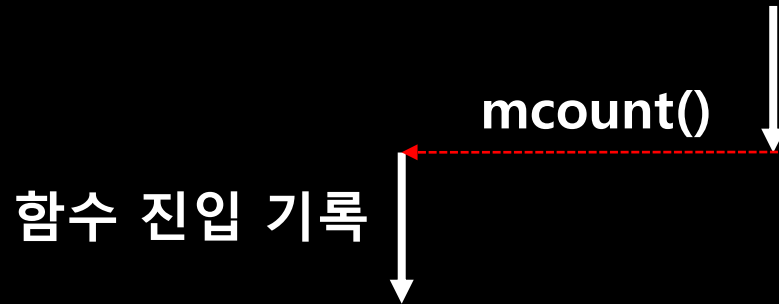
```
$ uftrace ./a.out
```

```
LD_PRELOAD=libmcount.so    a.out
```



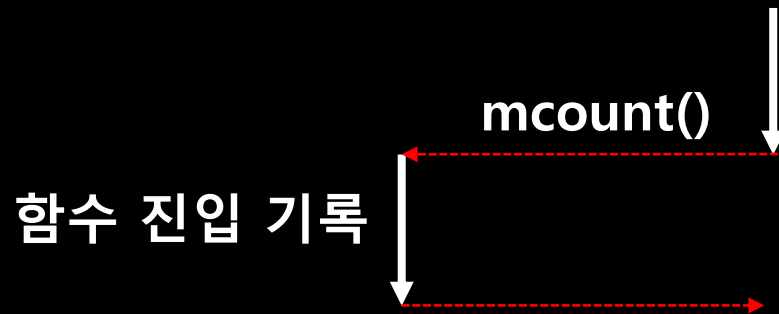
```
$ uftrace ./a.out
```

```
LD_PRELOAD=libmcount.so    a.out
```



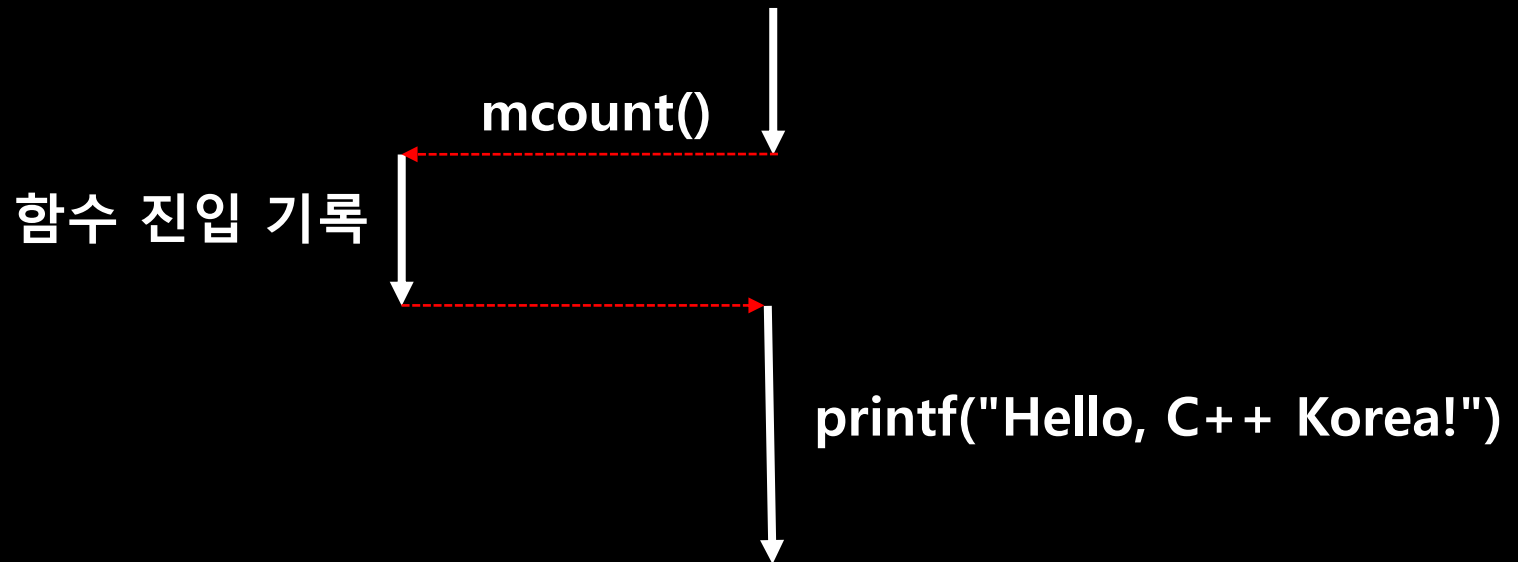
```
$ uftrace ./a.out
```

```
LD_PRELOAD=libmcount.so    a.out
```



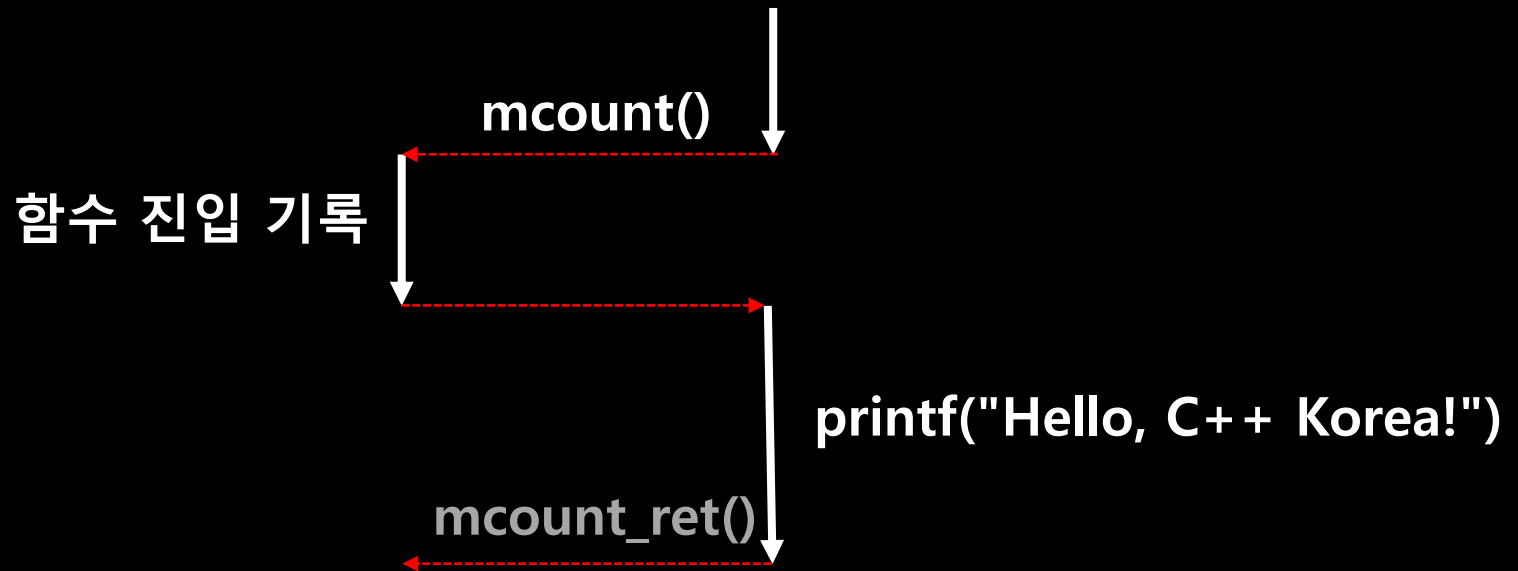
```
$ uftrace ./a.out
```

```
LD_PRELOAD=libmcount.so    a.out
```



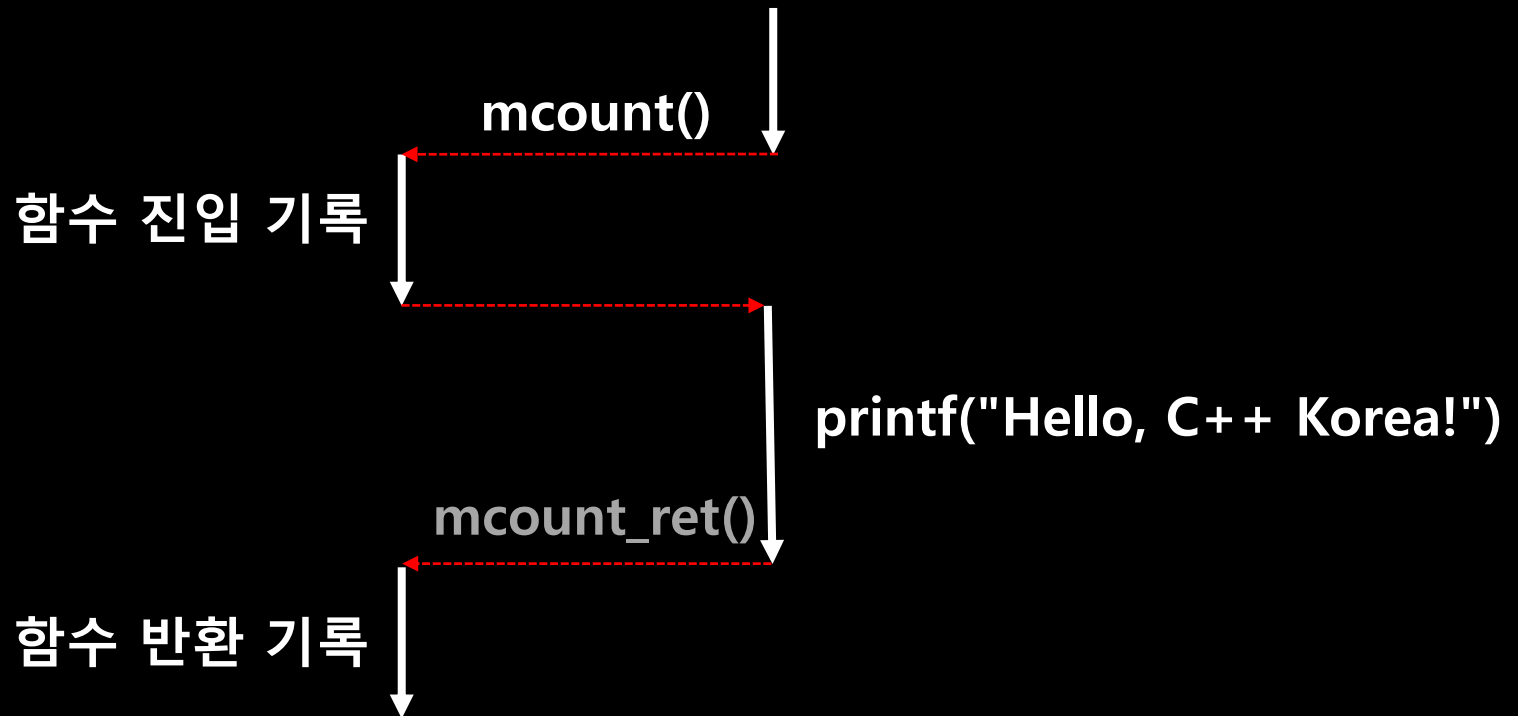
```
$ uftrace ./a.out
```

```
LD_PRELOAD=libmcount.so a.out
```



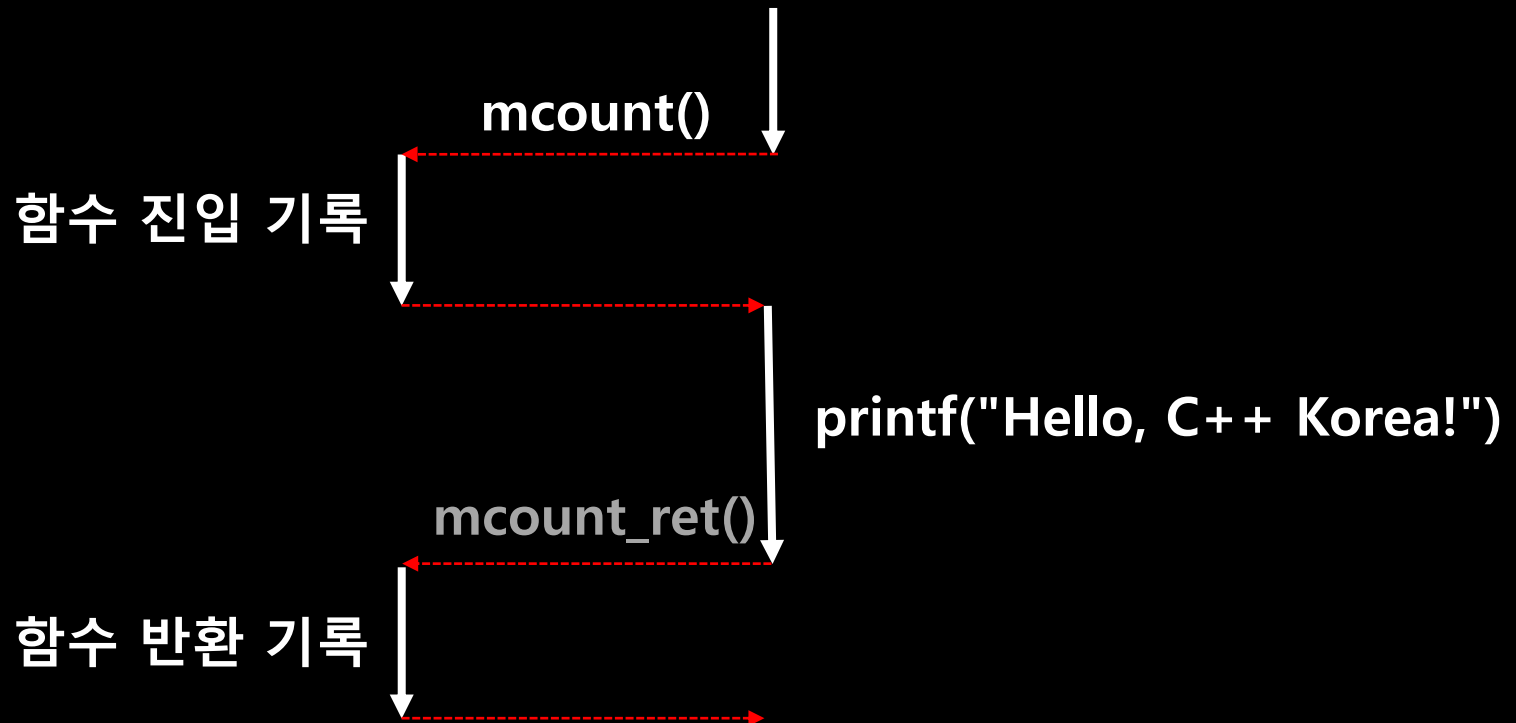
```
$ uftrace ./a.out
```

```
LD_PRELOAD=libmcount.so a.out
```



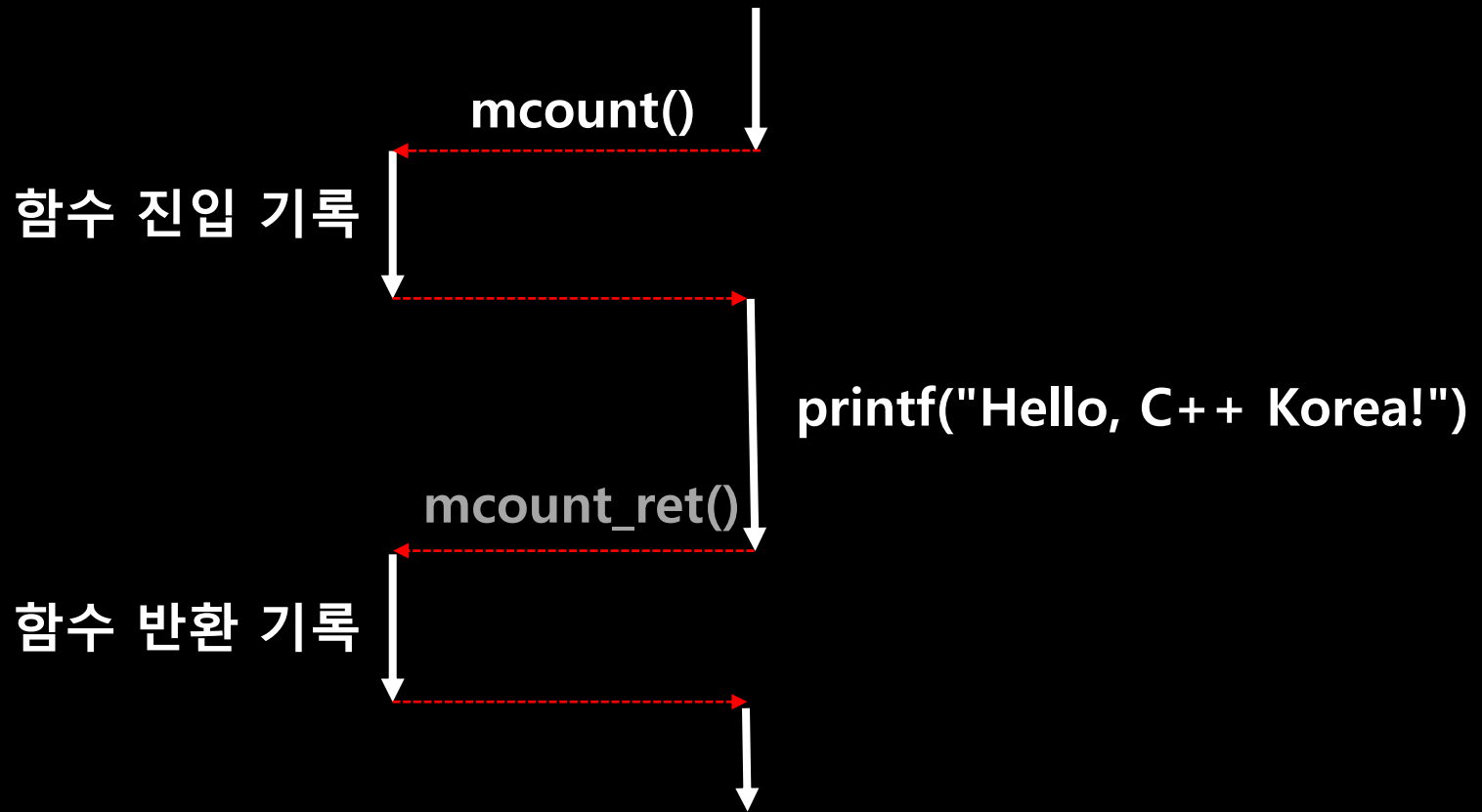
```
$ uftrace ./a.out
```

```
LD_PRELOAD=libmcount.so a.out
```



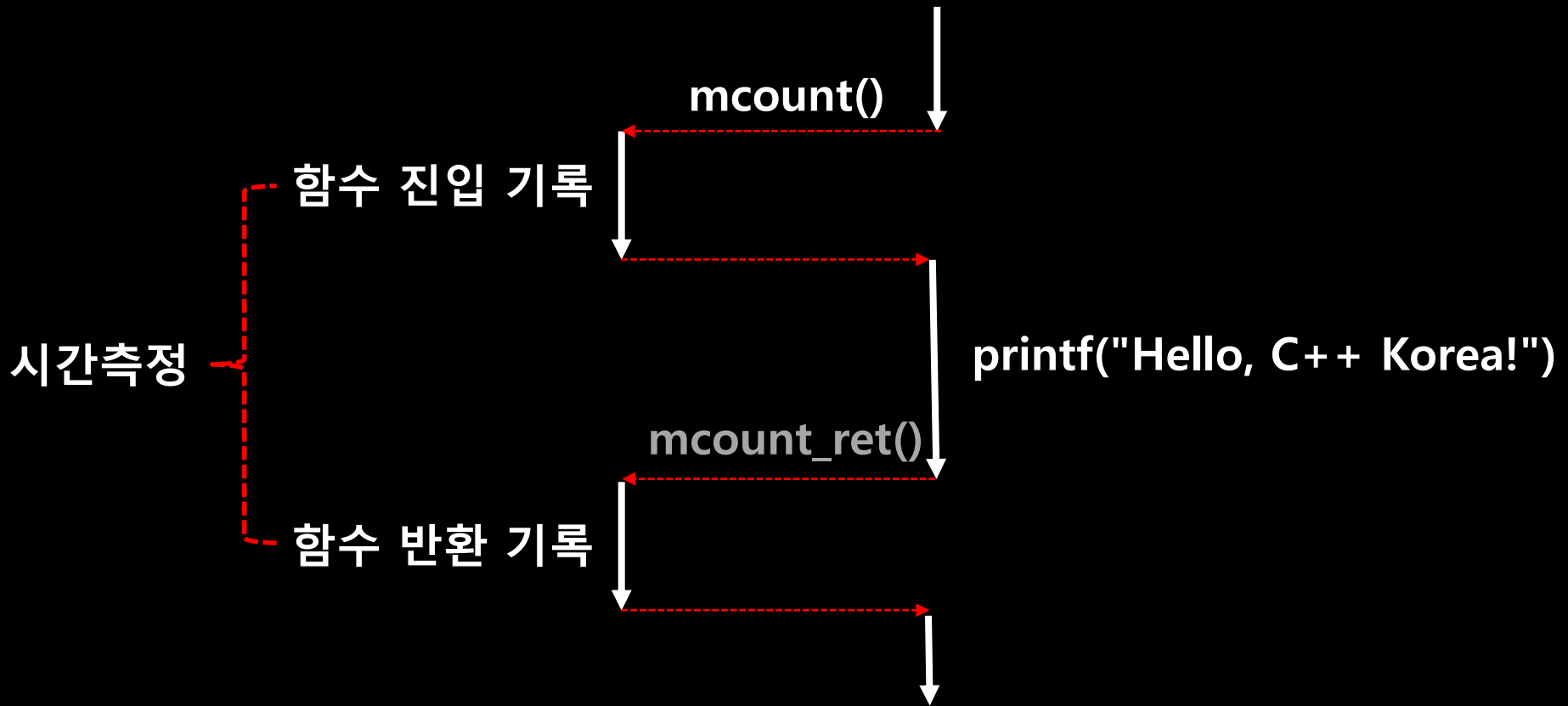

```
$ uftrace ./a.out
```

```
LD_PRELOAD=libmcount.so a.out
```



```
$ uftrace ./a.out
```

```
LD_PRELOAD=libmcount.so a.out
```



uftrace

C/C++ 프로그램의 함수 실행 흐름을 추적하는 도구

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

uftrace

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

Quick Installation

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

```
$ cd uftrace
```

```
# For Ubuntu Users
```

```
$ sudo apt-get install libdw-dev pandoc \  
    libpython2.7-dev libncursesw5-dev
```

```
$ make
```

```
$ sudo make install
```

Quick Installation

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

```
$ cd uftrace
```

```
# For Ubuntu Users
```

```
$ sudo misc/ubuntu-install-deps.sh
```

```
$ make
```

```
$ sudo make install
```

uftrace 패키지 설치 (Ubuntu 18.04)

```
honggyu@honggyu-VirtualBox: ~  
File Edit View Search Terminal Help  
honggyu@honggyu-VirtualBox:~$ uftrace  
  
Command 'uftrace' not found, but can be installed with:  
  
sudo apt install uftrace  
  
honggyu@honggyu-VirtualBox:~$ sudo apt install uftrace  
Reading package lists... Done  
Building dependency tree  
Reading state information... Done  
The following NEW packages will be installed:  
  uftrace  
0 upgraded, 1 newly installed, 0 to remove and 0 not upgraded.  
Need to get 251 kB of archives.  
After this operation, 1,022 kB of additional disk space will be used.  
Get:1 http://kr.archive.ubuntu.com/ubuntu bionic/universe amd64 uftrace amd64 0.8.2-1 [251 kB]  
Fetched 251 kB in 0s (3,777 kB/s)  
Selecting previously unselected package uftrace.  
(Reading database ... 139964 files and directories currently installed.)  
Preparing to unpack .../uftrace_0.8.2-1_amd64.deb ...  
Unpacking uftrace (0.8.2-1) ...  
Setting up uftrace (0.8.2-1) ...  
Processing triggers for man-db (2.8.3-2) ...  
honggyu@honggyu-VirtualBox:~$ uftrace  
Usage: uftrace [OPTION...]  
        [record|replay|live|report|info|dump|recv|graph|script]  
        [<program>]  
Try `uftrace --help' or `uftrace --usage' for more information.  
honggyu@honggyu-VirtualBox:~$
```

간단한 사용법

C/C++ (user) Function Tracing

- -pg 또는 다른 tracing 가능한 옵션으로 재컴파일 필요

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

C/C++ (user) Function Tracing

- -pg 또는 다른 tracing 가능한 옵션으로 재컴파일 필요

```
$ gcc test.c
```

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

C/C++ (user) Function Tracing

- -pg 또는 다른 tracing 가능한 옵션으로 재컴파일 필요

```
$ gcc test.c
```

<pre>void bar() {</pre>	<pre><bar>:</pre>
<pre> ret</pre>	<pre>ret</pre>
<pre>}</pre>	
<pre>void foo() {</pre>	<pre><foo>:</pre>
<pre> bar();</pre>	
<pre>}</pre>	<pre>call <bar></pre>
<pre>int main() {</pre>	<pre>ret</pre>
<pre> foo();</pre>	
<pre>}</pre>	<pre><main>:</pre>
	<pre>call <foo></pre>
	<pre>ret</pre>

C/C++ (user) Function Tracing

- -pg 또는 다른 tracing 가능한 옵션으로 재컴파일 필요

```
$ gcc -pg test.c
```

```
void bar() {  
    <bar>:  
    call <mcount@plt>  
    ret  
}  
void foo() {  
    bar();  
    <foo>:  
    call <mcount@plt>  
    call <bar>  
    ret  
}  
int main() {  
    foo();  
    <main>:  
    call <mcount@plt>  
    call <foo>  
    ret  
}
```

C/C++ (user) Function Tracing

- -pg 또는 다른 tracing 가능한 옵션으로 재컴파일 필요

```
$ gcc -finstrument-functions test.c
```

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

<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 <__cyg_profile_func_exit@plt>
    ret
```

C/C++ (user) Function Tracing

```
$ gcc -pg test.c
```

C/C++ (user) Function Tracing

```
$ gcc -pg test.c
```

```
$ ./a.out
```

C/C++ (user) Function Tracing

```
$ gcc -pg test.c  
$ uftrace record a.out
```

```
uftrace record
```

- Run a command and record its trace data

C/C++ (user) Function Tracing

```
$ gcc -pg test.c
$ uftrace record a.out
$ uftrace replay
```

#	DURATION	TID	FUNCTION
	1.293 us	[11558]	__monstartup();
	0.814 us	[11558]	__cxa_atexit();
		[11558]	main() {
		[11558]	foo() {
	0.156 us	[11558]	bar();
	0.767 us	[11558]	} /* foo */
	1.140 us	[11558]	} /* main */

```
uftrace replay
```

- Print recorded function trace

C/C++ (user) Function Tracing

```
$ gcc -pg test.c
```

```
$ uftrace live a.out
```

#	DURATION	TID	FUNCTION
	1.293 us	[11558]	__monstartup();
	0.814 us	[11558]	__cxa_atexit();
		[11558]	main() {
		[11558]	foo() {
	0.156 us	[11558]	bar();
	0.767 us	[11558]	} /* foo */
	1.140 us	[11558]	} /* main */

```
uftrace live
```

- Trace functions in a command during live execution same as uftrace record and replay

C/C++ (user) Function Tracing

```
$ gcc -pg test.c
```

```
$ uftrace a.out
```

#	DURATION	TID	FUNCTION
	1.293 us	[11558]	__monstartup();
	0.814 us	[11558]	__cxa_atexit();
		[11558]	main() {
		[11558]	foo() {
	0.156 us	[11558]	bar();
	0.767 us	[11558]	} /* foo */
	1.140 us	[11558]	} /* main */

uftrace (live)

- Trace functions in a command during live execution same as uftrace record and replay

C/C++ (user) Function Tracing

```
$ gcc -pg test.c
```

```
$ uftrace a.out
```

#	DURATION	TID	FUNCTION
	1.293 us	[11558]	__monstartup();
	0.814 us	[11558]	__cxa_atexit();
		[11558]	main() {
		[11558]	foo() {
	0.156 us	[11558]	bar();
	0.767 us	[11558]	} /* foo */
	1.140 us	[11558]	} /* main */

C/C++ (user) Function Tracing

```
$ gcc -pg test.c
```

```
$ uftrace a.out
```

#	DURATION	TID	FUNCTION
	1.293 us	[11558]	__monstartup();
	0.814 us	[11558]	__cxa_atexit();
		[11558]	main() {
		[11558]	foo() {
	0.156 us	[11558]	bar();
	0.767 us	[11558]	} /* foo */
	1.140 us	[11558]	} /* main */

C/C++ (user) Function Tracing

```
$ gcc -pg test.c
```

```
$ uftrace a.out
```

#	DURATION	TID	FUNCTION
	1.293 us	[11558]	__monstartup();
	0.814 us	[11558]	__cxa_atexit();
		[11558]	main() {
		[11558]	foo() {
	0.156 us	[11558]	bar();
	0.767 us	[11558]	} /* foo */
	1.140 us	[11558]	} /* main */

C/C++ (user) Function Tracing

```
$ gcc -pg test.c
```

```
$ uftrace a.out
```

#	DURATION	TID	FUNCTION
	1.293 us	[11558]	__monstartup();
	0.814 us	[11558]	__cxa_atexit();
		[11558]	main() {
		[11558]	foo() {
	0.156 us	[11558]	bar();
	0.767 us	[11558]	} /* foo */
	1.140 us	[11558]	} /* main */

Library Function Tracing

- PLT hooking 을 통해 라이브러리 함수 호출 추적 가능

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


Library Function Tracing

- PLT hooking 을 통해 라이브러리 함수 호출 추적 가능

```
$ gcc -pg test.c
```

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

Library Function Tracing

- PLT hooking 을 통해 라이브러리 함수 호출 추적 가능

```
$ gcc -pg test.c
```

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

```
<bar>:  
    call <mcount@plt>  
    call <getpid@plt> # indirect call in PLT  
    ret  
  
<foo>:  
    call <mcount@plt>  
    call <bar>  
    ret  
  
<main>:  
    call <mcount@plt>  
    call <foo>  
    ret
```

Library Function Tracing

```
$ gcc -pg test.c
```

```
$ uftrace a.out
```

```
Hello
```

#	DURATION	TID	FUNCTION
	1.087 us	[12411]	__monstartup();
	0.790 us	[12411]	__cxa_atexit();
		[12411]	main() {
		[12411]	foo() {
		[12411]	bar() {
	6.263 us	[12411]	getpid();
	7.016 us	[12411]	} /* bar */
	7.443 us	[12411]	} /* foo */
	7.826 us	[12411]	} /* main */

Library Function Tracing

```
$ uftrace tests/t-fork
```

```
# DURATION      TID      FUNCTION
      [14528] | main() {
127.033 us [14528] |   fork();
      [14528] |   wait() {
      [14540] |   } /* fork */
      [14540] |   a() {
      [14540] |       b() {
      [14540] |           c() {
1.507 us [14540] |               getpid();
2.987 us [14540] |           } /* c */
3.464 us [14540] |       } /* b */
3.854 us [14540] |   } /* a */
13.394 us [14540] | } /* main */
799.270 us [14528] | } /* wait */
      [14528] |   a() {
      [14528] |       b() {
      [14528] |           c() {
2.410 us [14528] |               getpid();
3.470 us [14528] |           } /* c */
3.833 us [14528] |       } /* b */
4.144 us [14528] |   } /* a */
952.797 us [14528] | } /* main */
```

Nested Library Tracing

```
$ uftrace --nest-libcall --auto-args \  
    /usr/bin/clang hello.c
```

--nest-libcall

Trace function calls between libraries.

By default, uftrace only record library call from the main executable.

라이브러리 내부에서 다른 라이브러리를
호출하는 것도 tracing 해야 할 때 사용

Nested Library Tracing

```
0.284 us [175968] | strlen("/usr/bin/ld") = 11;
                | llvm::sys::commandLineFitsWithinSystemLimits() {
...
21.584 us [175968] | } /* llvm::sys::commandLineFitsWithinSystemLimits */
0.197 us [175968] | llvm::opt::ArgList::getLastArg();
0.420 us [175968] | memcpy(0x7ffc7ba7a020, 0x28a07d0, 384) = 0x7ffc7ba7a020;
0.323 us [175968] | strlen("/usr/lib/llvm-3.8/bin/clang") = 27;
                | llvm::sys::ExecuteAndWait() {
0.360 us [175968] |     memcpy(0x7ffc7ba79b18, 0x2883dc0, 27) = 0x7ffc7ba79b18;
3.093 us [175968] |     access();
0.153 us [175968] |     std::_V2::system_category();
                | std::__cxx11::basic_string::_M_create() {
                |     operator new() {
0.490 us [175968] |         malloc(28) = 0x28a1150;
1.053 us [175968] |     } /* operator new */
1.566 us [175968] | } /* std::__cxx11::basic_string::_M_create */
0.253 us [175968] | memcpy(0x28a1150, 0x2883dc0, 27) = 0x28a1150;
247.286 us [175968] | posix_spawn();
                | operator delete() {
0.590 us [175968] |     free(0x28a1150);
1.500 us [175968] | } /* operator delete */
                | waitpid(175980, 0x7ffc7ba79bfc, 0) {
...

```

**재컴파일 없이 시스템에 배포된 clang 이미지에 적용해도
일부 라이브러리 함수 호출 확인 가능**

Linux Kernel Function Tracing

```
$ gcc -pg hello.c
```

Linux Kernel Function Tracing

```
$ gcc -pg hello.c
```

```
$ sudo uftrace -k a.out
```

```
Hello C++ Korea!
```


Linux Kernel Function Tracing

```
$ gcc -pg hello.c
```

```
$ sudo uftrace -k a.out
```

```
Hello C++ Korea!
```

#	DURATION	TID	FUNCTION
	0.395 us	[8926]	__monstartup();
	0.354 us	[8926]	__cxa_atexit();
		[8926]	main() {
		[8926]	printf() {
	0.572 us	[8926]	sys_newfstat();
	1.316 us	[8926]	__do_page_fault();
	4.123 us	[8926]	} /* puts */
		[8926]	fflush() {
	5.229 us	[8926]	sys_write();
	6.454 us	[8926]	} /* fflush */
	11.171 us	[8926]	} /* main */

리눅스 커널
내부 함수들

Event Tracing (sched event)

```
$ uftrace t-fork
```

#	DURATION	TID	FUNCTION
		[14983]	main() {
225.620	us	[14983]	fork();
		[14983]	wait() {
		[14995]	} /* fork */
		[14995]	a() {
		[14995]	b() {
		[14995]	c() {
1.033	us	[14995]	getpid();
2.280	us	[14995]	} /* c */
2.677	us	[14995]	} /* b */
3.020	us	[14995]	} /* a */
11.131	us	[14995]	} /* main */
695.312	us	[14983]	} /* wait */
		[14983]	a() {
		[14983]	b() {
		[14983]	c() {
2.067	us	[14983]	getpid();
3.067	us	[14983]	} /* c */
3.444	us	[14983]	} /* b */
3.841	us	[14983]	} /* a */
950.334	us	[14983]	} /* main */

Event Tracing (sched event)

```
$ uftrace -E linux:schedule t-fork
```

#	DURATION	TID	FUNCTION
		[14983]	main() {
225.620	us	[14983]	fork();
		[14983]	wait() {
		[14983]	/* linux:sched-out */
		[14995]	} /* fork */
		[14995]	a() {
		[14995]	b() {
		[14995]	c() {
1.033	us	[14995]	getpid();
2.280	us	[14995]	} /* c */
2.677	us	[14995]	} /* b */
3.020	us	[14995]	} /* a */
11.131	us	[14995]	} /* main */
676.988	us	[14983]	/* linux:sched-in */
695.312	us	[14983]	} /* wait */
		[14983]	a() {
		[14983]	b() {
		[14983]	c() {
2.067	us	[14983]	getpid();
3.067	us	[14983]	} /* c */
3.444	us	[14983]	} /* b */
3.841	us	[14983]	} /* a */
950.334	us	[14983]	} /* main */

PMU: Performance Monitoring Unit

```
$ uftrace -T main@read=pmu-cycle t-abc
```

PMU: Performance Monitoring Unit

```
$ uftrace record -T main@read=pmu-cycle t-abc
```

```
$ uftrace replay -f duration
```

```
# DURATION      FUNCTION
  1.466 us | __monstartup();
  1.127 us | __cxa_atexit();
           | main() {
           |     /* read:pmu-cycle
           |        (cycle=158792, instructions=89990) */
           |     a() {
           |         b() {
           |             c() {
1.050 us |                 getpid();
2.786 us |             } /* c */
3.447 us |         } /* b */
4.003 us |     } /* a */
           |     /* diff:pmu-cycle
           |        (cycle=+6119, instructions=+5641, IPC=0.92) */
9.520 us | } /* main */
```

PMU: Performance Monitoring Unit

```
$ uftrace record -T main@read=pmu-cycle t-abc
```

```
$ uftrace replay -f duration
```

```
# DURATION      FUNCTION
  1.466 us | __monstartup();
  1.127 us | __cxa_atexit();
           | main() {
           |     /* read:pmu-cycle
           |        (cycle=158792, instructions=89990) */
           |     a() {
           |         b() {
           |             c() {
1.050 us |                 getpid();
2.786 us |             } /* c */
3.447 us |         } /* b */
4.003 us |     } /* a */
           |     /* diff:pmu-cycle
           |        (cycle=+6119, instructions=+5641, IPC=0.92) */
9.520 us | } /* main */
```

함수 진입부터 반환 시점까지 진행된
cycle 수와 명령어 개수 정보

다른 **read trigger** 이벤트들

-T <func>@**read=<event>**

\$ man ufttrace record

...

The **read trigger** is to read some information at runtime. The result will be recorded as (builtin) events at the beginning and the end of a given function. As of now, following **events** are supported:

- "proc/statm": process memory stat from /proc filesystem
- "page-fault": number of page faults using getrusage(2)
- "pmu-cycle": cpu cycles and instructions using Linux perf-event syscall
- "pmu-cache": (cpu) cache-references and misses using Linux perf-event syscall
- "pmu-branch": branch instructions and misses using Linux perf-event syscall

Filters

불필요한 함수가 너무 많을 때 사용하는 필터들


```
$ gcc -pg test.c
```

```
$ uftrace a.out
```

#	DURATION	TID	FUNCTION
	0.531 us	[21315]	__monstartup();
	0.435 us	[21315]	__cxa_atexit();
		[21315]	main() {
		[21315]	foo() {
	0.134 us	[21315]	bar();
	0.564 us	[21315]	} /* foo */
	0.890 us	[21315]	} /* main */

```
$ gcc -pg test.c
```

```
$ uftrace -D 2 a.out
```

#	DURATION	TID	FUNCTION
	0.531 us	[21315]	__monstartup();
	0.435 us	[21315]	__cxa_atexit();
		[21315]	main() {
		[21315]	foo() {
	0.134 us	[21315]	bar();
	0.564 us	[21315]	} /* foo */
	0.890 us	[21315]	} /* main */

```
$ gcc -pg test.c
```

```
$ uftrace -D 2 a.out
```

#	DURATION	TID	FUNCTION
	0.531 us	[21315]	__monstartup();
	0.435 us	[21315]	__cxa_atexit();
		[21315]	main() {
		[21315]	foo() {
	0.134 us	[21315]	bar();
	0.564 us	[21315]	} /* foo */
	0.890 us	[21315]	} /* main */

-D DEPTH, --depth=DEPTH

Set global trace limit in nesting level.

```
$ gcc -pg test.c
```

```
$ uftrace -D 2 a.out
```

#	DURATION	TID	FUNCTION
	0.648 us	[32431]	__monstartup();
	0.480 us	[32431]	__cxa_atexit();
		[32431]	main() {
	0.215 us	[32431]	foo();
	0.717 us	[32431]	} /* main */

-D DEPTH, --depth=DEPTH

Set global trace limit in nesting level.

```
$ gcc -pg test.c
```

```
$ uftrace -F foo a.out
```

#	DURATION	TID	FUNCTION
	0.531 us	[21315]	__monstartup();
	0.435 us	[21315]	__cxa_atexit();
		[21315]	main() {
		[21315]	foo() {
	0.134 us	[21315]	bar();
	0.564 us	[21315]	} /* foo */
	0.890 us	[21315]	} /* main */

```
$ gcc -pg test.c
```

```
$ uftrace -F foo a.out
```

#	DURATION	TID	FUNCTION
	0.531 us	[21315]	__monstartup();
	0.435 us	[21315]	__cxa_atexit();
		[21315]	main() {
		[21315]	foo() {
	0.134 us	[21315]	bar();
	0.564 us	[21315]	} /* foo */
	0.890 us	[21315]	} /* main */

-F FUNC, --filter=FUNC

Set filter to trace selected functions only.

```
$ gcc -pg test.c
```

```
$ uftrace -F foo a.out
```

```
# DURATION      TID      FUNCTION
           [32432] | foo() {
0.175 us [32432] |   bar();
1.137 us [32432] | } /* foo */
```

```
-F FUNC, --filter=FUNC
```

Set filter to trace selected functions only.

```
$ gcc -pg test.c
```

```
$ uftrace -N foo a.out
```

#	DURATION	TID	FUNCTION
	0.531 us	[21315]	__monstartup();
	0.435 us	[21315]	__cxa_atexit();
		[21315]	main() {
		[21315]	foo() {
	0.134 us	[21315]	bar();
	0.564 us	[21315]	} /* foo */
	0.890 us	[21315]	} /* main */


```
$ gcc -pg test.c
```

```
$ uftrace -N foo a.out
```

```
# DURATION      TID      FUNCTION
    0.531 us [21315] | __monstartup();
    0.435 us [21315] | __cxa_atexit();
           [21315] | main() {
           [21315] |     foo() {
    0.134 us [21315] |         bar();
    0.564 us [21315] |     } /* foo */
    0.890 us [21315] | } /* main */
```

-N FUNC, --notrace=FUNC

Set filter not to trace selected functions
(and children)

```
$ gcc -pg test.c
```

```
$ uftrace -N foo a.out
```

#	DURATION	TID	FUNCTION
	0.728 us	[32436]	__monstartup();
	0.505 us	[32436]	__cxa_atexit();
	0.741 us	[32436]	main();

-N FUNC, --notrace=FUNC

Set filter not to trace selected functions
(and children)

```
$ gcc -pg test.c
```

```
$ uftrace -t 200ns a.out
```

#	DURATION	TID	FUNCTION
	0.531 us	[21315]	__monstartup();
	0.435 us	[21315]	__cxa_atexit();
		[21315]	main() {
		[21315]	foo() {
	0.134 us	[21315]	bar();
	0.564 us	[21315]	} /* foo */
	0.890 us	[21315]	} /* main */

```
$ gcc -pg test.c
```

```
$ uftrace -t 200ns a.out
```

#	DURATION	TID	FUNCTION
	0.531 us	[21315]	__monstartup();
	0.435 us	[21315]	__cxa_atexit();
		[21315]	main() {
		[21315]	foo() {
	0.134 us	[21315]	bar();
	0.564 us	[21315]	} /* foo */
	0.890 us	[21315]	} /* main */

```
-t TIME, --time-filter=TIME
```

Do not show small functions under the
time threshold.

```
$ gcc -pg test.c
```

```
$ uftrace -t 200ns a.out
```

#	DURATION	TID	FUNCTION
	0.531 us	[21315]	__monstartup();
	0.435 us	[21315]	__cxa_atexit();
		[21315]	main() {
	0.564 us	[21315]	foo();
	0.890 us	[21315]	} /* main */

-t TIME, --time-filter=TIME

Do not show small functions under the
time threshold.

Report

시간 순서가 아닌 전체 결과에 대한 통합 결과

```
$ gcc -pg test.c
```

```
$ gcc -pg test.c
```

```
$ uftrace record a.out
```



```
$ gcc -pg test.c  
$ uftrace record a.out  
$ uftrace report
```

uftrace report

- Print statistics and summary for trace data

```
$ gcc -pg test.c
$ uftrace record a.out
$ uftrace report
```

Total time	Self time	Calls	Function
=====	=====	=====	=====
0.890 us	0.326 us	1	main
0.564 us	0.430 us	1	foo
0.531 us	0.531 us	1	__monstartup
0.435 us	0.435 us	1	__cxa_atexit
0.134 us	0.134 us	1	bar

```
uftrace report
```

- Print statistics and summary for trace data

```
$ gcc -pg test.c
$ uftrace record a.out
$ uftrace report -s total
```

Total time	Self time	Calls	Function
=====	=====	=====	=====
0.890 us	0.326 us	1	main
0.564 us	0.430 us	1	foo
0.531 us	0.531 us	1	__monstartup
0.435 us	0.435 us	1	__cxa_atexit
0.134 us	0.134 us	1	bar

uftrace report

- Print statistics and summary for trace data

```
$ gcc -pg test.c
$ uftrace record a.out
$ uftrace report -s self
```

Total time	Self time	Calls	Function
=====	=====	=====	=====
0.531 us	0.531 us	1	__monstartup
0.435 us	0.435 us	1	__cxa_atexit
0.564 us	0.430 us	1	foo
0.890 us	0.326 us	1	main
0.134 us	0.134 us	1	bar

uftrace report

- Print statistics and summary for trace data

```
$ gcc -pg test.c
$ uftrace record a.out
$ uftrace report -s call
```

Total time	Self time	Calls	Function
=====	=====	=====	=====
0.890 us	0.326 us	1	main
0.564 us	0.430 us	1	foo
0.531 us	0.531 us	1	__monstartup
0.435 us	0.435 us	1	__cxa_atexit
0.134 us	0.134 us	1	bar

uftrace report

- Print statistics and summary for trace data

Recording Function Arguments and Return Values

함수 인자값과 반환값을 함께 기록하는 방법

```
$ gcc -pg fibonacci.c
```

```
$ gcc -pg fibonacci.c  
$ uftrace ./a.out 5  
fib(5) = 5
```



```
$ gcc -pg fibonacci.c
```

```
$ uftrace ./a.out 5
```

```
fib(5) = 5
```

#	DURATION	TID	FUNCTION
	0.620 us	[31321]	__monstartup();
	0.456 us	[31321]	__cxa_atexit();
		[31321]	main() {
	1.478 us	[31321]	atoi();
		[31321]	fib() {
		[31321]	fib() {
		[31321]	fib() {
	0.155 us	[31321]	fib();
	0.123 us	[31321]	fib();
	0.883 us	[31321]	} /* fib */
	0.125 us	[31321]	fib();
	1.483 us	[31321]	} /* fib */
		[31321]	fib() {
	0.125 us	[31321]	fib();
	0.125 us	[31321]	fib();
	0.774 us	[31321]	} /* fib */
	2.716 us	[31321]	} /* fib */
	4.382 us	[31321]	printf();
	9.456 us	[31321]	} /* main */

```
$ gcc -pg fibonacci.c
```

```
$ uftrace -A fib@arg1 ./a.out 5
```

```
fib(5) = 5
```

#	DURATION	TID	FUNCTION
	0.770 us	[31365]	__monstartup();
	0.492 us	[31365]	__cxa_atexit();
		[31365]	main() {
	1.507 us	[31365]	atoi();
		[31365]	fib(5) {
		[31365]	fib(4) {
		[31365]	fib(3) {
	1.293 us	[31365]	fib(2);
	0.172 us	[31365]	fib(1);
	2.295 us	[31365]	} /* fib */
	0.157 us	[31365]	fib(2);
	3.025 us	[31365]	} /* fib */
		[31365]	fib(3) {
	0.150 us	[31365]	fib(2);
	0.155 us	[31365]	fib(1);
	0.917 us	[31365]	} /* fib */
	5.232 us	[31365]	} /* fib */
	4.856 us	[31365]	printf();
	12.697 us	[31365]	} /* main */

```
$ gcc -pg fibonacci.c
```

```
$ uftrace -A fib@arg1 -R fib@retval ./a.out 5
```

```
fib(5) = 5
```

#	DURATION	TID	FUNCTION
	0.718 us	[31379]	__monstartup();
	0.464 us	[31379]	__cxa_atexit();
		[31379]	main() {
	1.442 us	[31379]	atoi();
		[31379]	fib(5) {
		[31379]	fib(4) {
		[31379]	fib(3) {
	1.395 us	[31379]	fib(2) = 1;
	0.174 us	[31379]	fib(1) = 1;
	2.562 us	[31379]	} = 2; /* fib */
	0.157 us	[31379]	fib(2) = 1;
	3.330 us	[31379]	} = 3; /* fib */
		[31379]	fib(3) {
	0.152 us	[31379]	fib(2) = 1;
	0.154 us	[31379]	fib(1) = 1;
	0.959 us	[31379]	} = 2; /* fib */
	5.351 us	[31379]	} = 5; /* fib */
	5.729 us	[31379]	printf();
	13.627 us	[31379]	} /* main */

```
$ uftrace -A fib@arg1 -R fib@retval ./a.out 5
```

ARGUMENTS

```
<argument>      := <symbol> "@" <specs>
<specs>         := <spec> | <spec> "," <spec>
<spec>          := ( <int_spec> | <float_spec> | <ret_spec> )
<int_spec>      := "arg" N [ "/" <format> [ <size> ] ] [ "%" ( <reg> | <stack> ) ]
<float_spec>    := "fparg" N [ "/" ( <size> | "80" ) ] [ "%" ( <reg> | <stack> ) ]
<ret_spec>      := "retval" [ "/" <format> [ <size> ] ]
<format>        := "i" | "u" | "x" | "s" | "c" | "f" | "S"
<size>          := "8" | "16" | "32" | "64"
<reg>           := <arch-specific register name> # "rdi", "xmm0", "r0", ...
<stack>        := "stack" [ "+" ] <offset>
```

```
$ uftrace -A fib@arg1 -R fib@retval ./a.out 5
```

ARGUMENTS

```
<argument>      := <symbol> "@" <specs>
<specs>         := <spec> | <spec> "," <spec>
<spec>          := ( <int_spec> | <float_spec> | <ret_spec> )
<int_spec>      := "arg" N [ "/" <format> [ <size> ] ] [ "%" ( <reg> | <stack> ) ]
<float_spec>    := "fparg" N [ "/" ( <size> | "80" ) ] [ "%" ( <reg> | <stack> ) ]
<ret_spec>      := "retval" [ "/" <format> [ <size> ] ]
<format>        := "i" | "u" | "x" | "s" | "c" | "f" | "S"
<size>          := "8" | "16" | "32" | "64"
<reg>           := <arch-specific register name> # "rdi", "xmm0", "r0", ...
<stack>        := "stack" [ "+" ] <offset>
```

```
$ uftrace -A fib@arg1 -R fib@retval ./a.out 5
```

ARGUMENTS

```
<argument>      := <symbol> "@" <specs>
<specs>         := <spec> | <spec> "," <spec>
<spec>          := ( <int_spec> | <float_spec> | <ret_spec> )
<int_spec>      := "arg" N [ "/" <format> [ <size> ] ] [ "%" ( <reg> | <stack> ) ]
<float_spec>    := "fparg" N [ "/" ( <size> | "80" ) ] [ "%" ( <reg> | <stack> ) ]
<ret_spec>      := "retval" [ "/" <format> [ <size> ] ]
<format>        := "i" | "u" | "x" | "s" | "c" | "f" | "S"
<size>          := "8" | "16" | "32" | "64"
<reg>           := <arch-specific register name> # "rdi", "xmm0", "r0", ...
<stack>        := "stack" [ "+" ] <offset>
```

```
$ uftrace -A fib@arg1 -R fib@retval ./a.out 5
```

ARGUMENTS

```
<argument>      := <symbol> "@" <specs>
<specs>         := <spec> | <spec> "," <spec>
<spec>          := ( <int_spec> | <float_spec> | <ret_spec> )
<int_spec>      := "arg" N [ "/" <format> [ <size> ] ] [ "%" ( <reg> | <stack> ) ]
<float_spec>    := "fparg" N [ "/" ( <size> | "80" ) ] [ "%" ( <reg> | <stack> ) ]
<ret_spec>      := "retval" [ "/" <format> [ <size> ] ]
<format>        := "i" | "u" | "x" | "s" | "c" | "f" | "S"
<size>          := "8" | "16" | "32" | "64"
<reg>           := <arch-specific register name> # "rdi", "xmm0", "r0", ...
<stack>        := "stack" [ "+" ] <offset>
```

uftrace with DWARF

(a standardized debugging data format)

함수 인자와 반환 타입 자동 인식

-a / --auto-args option


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

```
$ uftrace ./a.out 5
```

```
fib(5) = 5
```

#	DURATION	TID	FUNCTION
	0.620 us	[31321]	__monstartup();
	0.456 us	[31321]	__cxa_atexit();
		[31321]	main() {
	1.478 us	[31321]	atoi();
		[31321]	fib() {
		[31321]	fib() {
		[31321]	fib() {
	0.155 us	[31321]	fib();
	0.123 us	[31321]	fib();
	0.883 us	[31321]	} /* fib */
	0.125 us	[31321]	fib();
	1.483 us	[31321]	} /* fib */
		[31321]	fib() {
	0.125 us	[31321]	fib();
	0.125 us	[31321]	fib();
	0.774 us	[31321]	} /* fib */
	2.716 us	[31321]	} /* fib */
	4.382 us	[31321]	printf();
	9.456 us	[31321]	} /* main */

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

```
$ uftrace --auto-args ./a.out 5
```

```
fib(5) = 5
```

#	DURATION	TID	FUNCTION
	0.718 us	[31379]	__monstartup();
	0.464 us	[31379]	__cxa_atexit();
		[31379]	main(2, 0x7ffc8dc59d98) {
	1.442 us	[31379]	atoi();
		[31379]	fib(5) {
		[31379]	fib(4) {
		[31379]	fib(3) {
	1.395 us	[31379]	fib(2) = 1;
	0.174 us	[31379]	fib(1) = 1;
	2.562 us	[31379]	} = 2; /* fib */
	0.157 us	[31379]	fib(2) = 1;
	3.330 us	[31379]	} = 3; /* fib */
		[31379]	fib(3) {
	0.152 us	[31379]	fib(2) = 1;
	0.154 us	[31379]	fib(1) = 1;
	0.959 us	[31379]	} = 2; /* fib */
	5.351 us	[31379]	} = 5; /* fib */
	5.729 us	[31379]	printf("%d\n") = 2;
	13.627 us	[31379]	} = 0; /* main */

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

```
$ uftrace -a ./a.out 5
```

```
fib(5) = 5
```

#	DURATION	TID	FUNCTION
	0.718 us	[31379]	__monstartup();
	0.464 us	[31379]	__cxa_atexit();
		[31379]	main(2, 0x7ffc8dc59d98) {
	1.442 us	[31379]	atoi();
		[31379]	fib(5) {
		[31379]	fib(4) {
		[31379]	fib(3) {
	1.395 us	[31379]	fib(2) = 1;
	0.174 us	[31379]	fib(1) = 1;
	2.562 us	[31379]	} = 2; /* fib */
	0.157 us	[31379]	fib(2) = 1;
	3.330 us	[31379]	} = 3; /* fib */
		[31379]	fib(3) {
	0.152 us	[31379]	fib(2) = 1;
	0.154 us	[31379]	fib(1) = 1;
	0.959 us	[31379]	} = 2; /* fib */
	5.351 us	[31379]	} = 5; /* fib */
	5.729 us	[31379]	printf("%d\n") = 2;
	13.627 us	[31379]	} = 0; /* main */

Visualization

uftrace dump
--chrome / --flame-graph

```
$ gcc -pg fibonacci.c
```

```
$ gcc -pg fibonacci.c  
$ uftrace record ./a.out 5  
fib(5) = 5
```

```
$ gcc -pg fibonacci.c  
$ uftrace record ./a.out 5  
fib(5) = 5  
$ uftrace dump
```

uftrace dump

- Print raw tracing data in the data files

```
$ gcc -pg fibonacci.c  
$ uftrace record ./a.out 5  
fib(5) = 5  
$ uftrace dump --chrome
```

--chrome

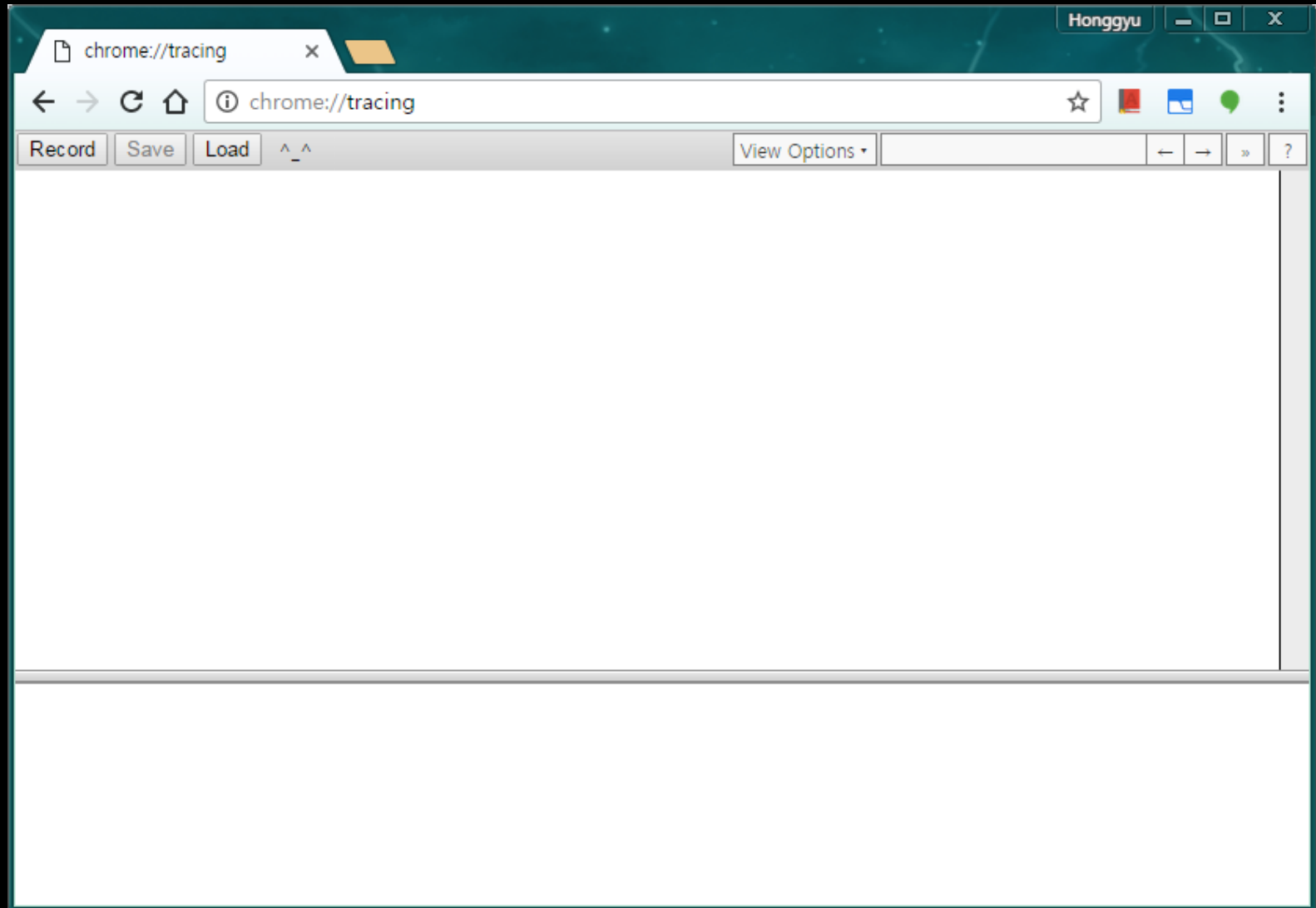
Show JSON style output as used by the Google Chrome tracing facility.


```
$ gcc -pg fibonacci.c
$ uftrace record ./a.out 5
fib(5) = 5
$ uftrace dump --chrome
```

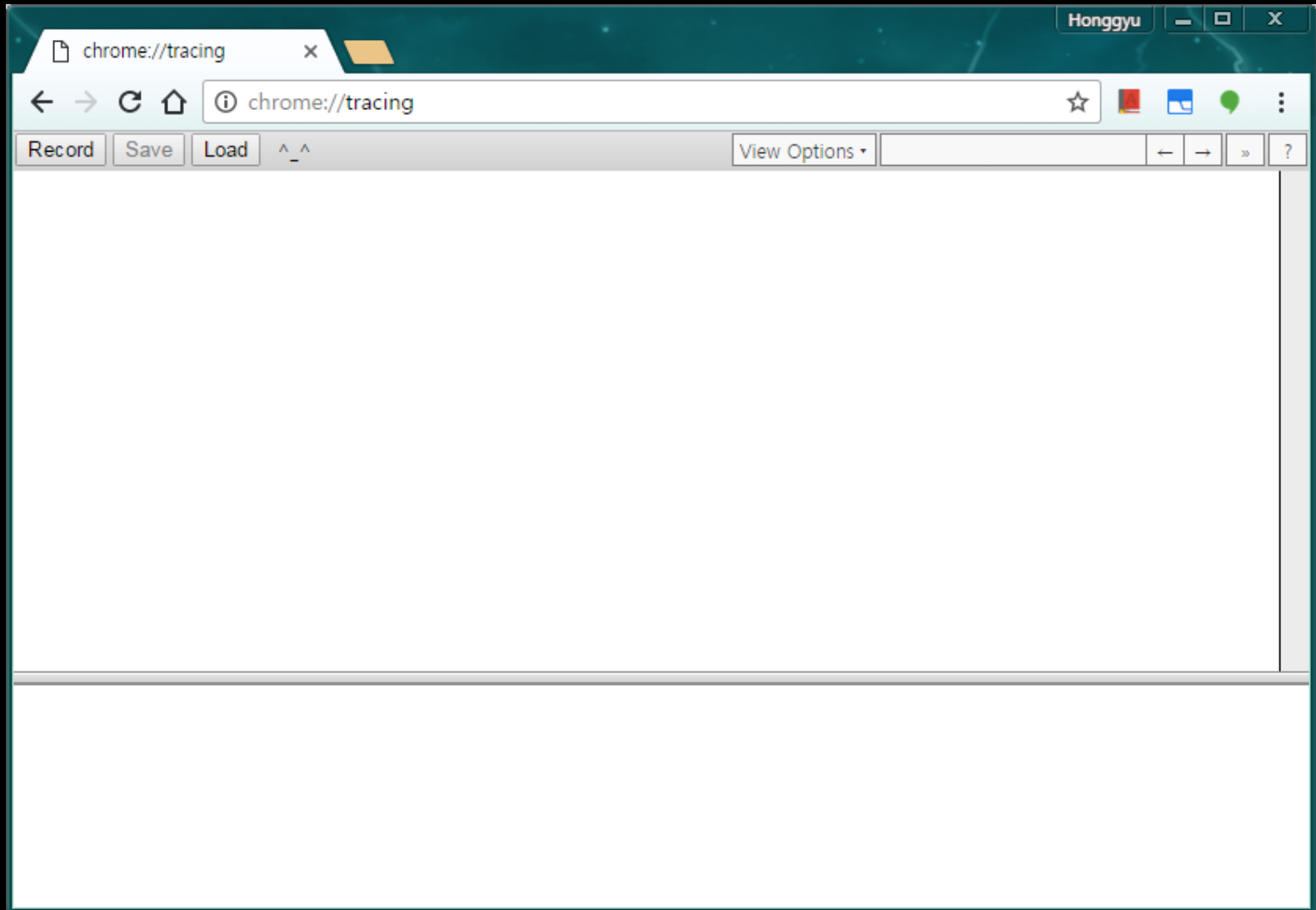
```
{ "traceEvents": [
  { "ts": 5913706403443, "ph": "B", "pid": 32256, "name": "__monstartup" },
  { "ts": 5913706403444, "ph": "E", "pid": 32256, "name": "__monstartup" },
  { "ts": 5913706403447, "ph": "B", "pid": 32256, "name": "__cxa_atexit" },
  { "ts": 5913706403447, "ph": "E", "pid": 32256, "name": "__cxa_atexit" },
  { "ts": 5913706403448, "ph": "B", "pid": 32256, "name": "main" },
  { "ts": 5913706403448, "ph": "B", "pid": 32256, "name": "atoi" },
  { "ts": 5913706403450, "ph": "E", "pid": 32256, "name": "atoi" },
  { "ts": 5913706403450, "ph": "B", "pid": 32256, "name": "fib" },
  { "ts": 5913706403450, "ph": "B", "pid": 32256, "name": "fib" },
    ...
  { "ts": 5913706403452, "ph": "E", "pid": 32256, "name": "fib" },
  { "ts": 5913706403453, "ph": "E", "pid": 32256, "name": "fib" },
  { "ts": 5913706403453, "ph": "E", "pid": 32256, "name": "fib" },
  { "ts": 5913706403453, "ph": "B", "pid": 32256, "name": "printf" },
  { "ts": 5913706403457, "ph": "E", "pid": 32256, "name": "printf" },
  { "ts": 5913706403458, "ph": "E", "pid": 32256, "name": "main" }
], "metadata": {
  "command_line": "uftrace record fibonacci 5 ",
  "recorded_time": "Thu Sep 22 22:31:17 2016"
} }
```

```
$ gcc -pg fibonacci.c  
$ uftrace record ./a.out 5  
fib(5) = 5  
$ uftrace dump --chrome > fib.json
```

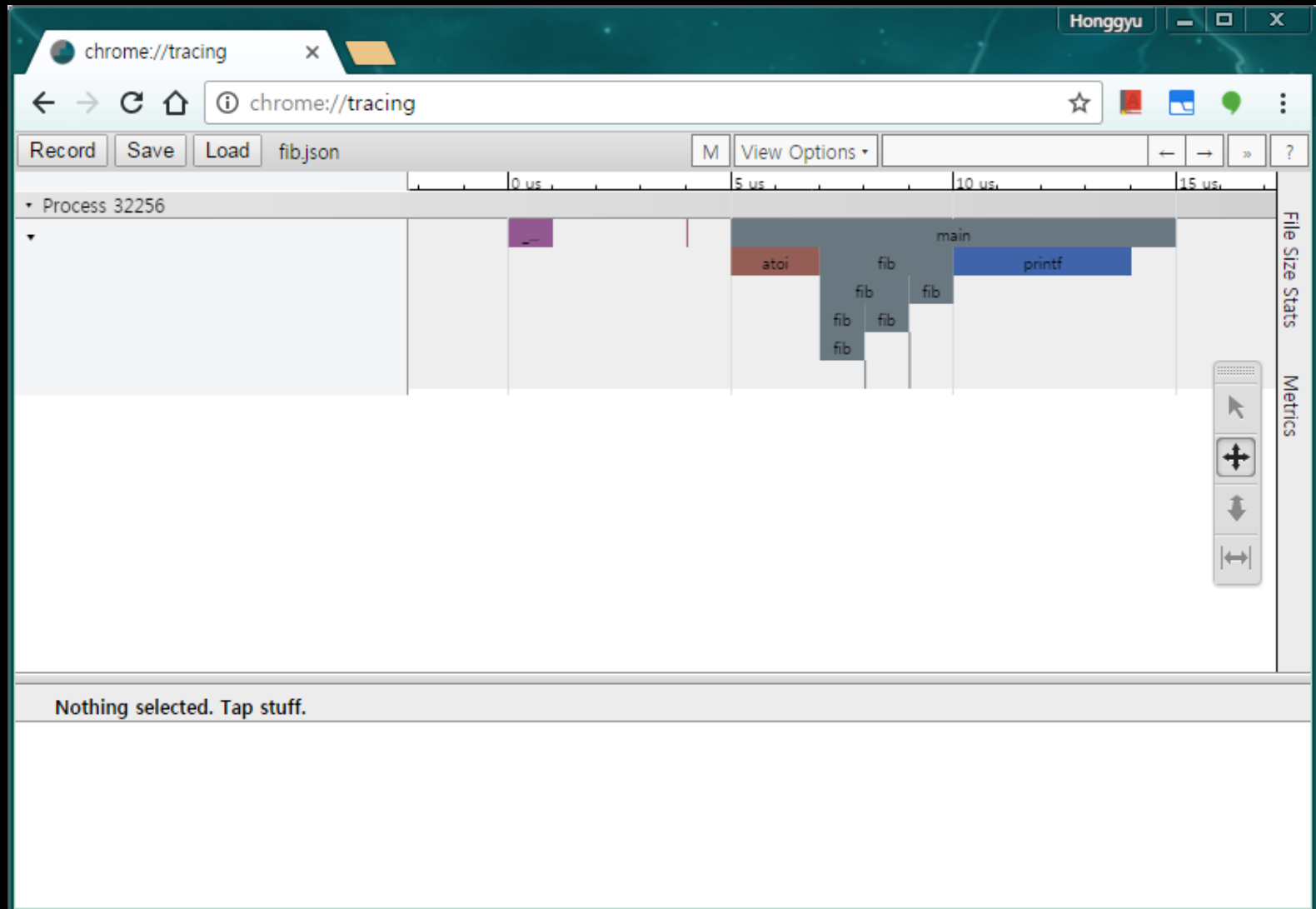
1. Open Chrome Browser



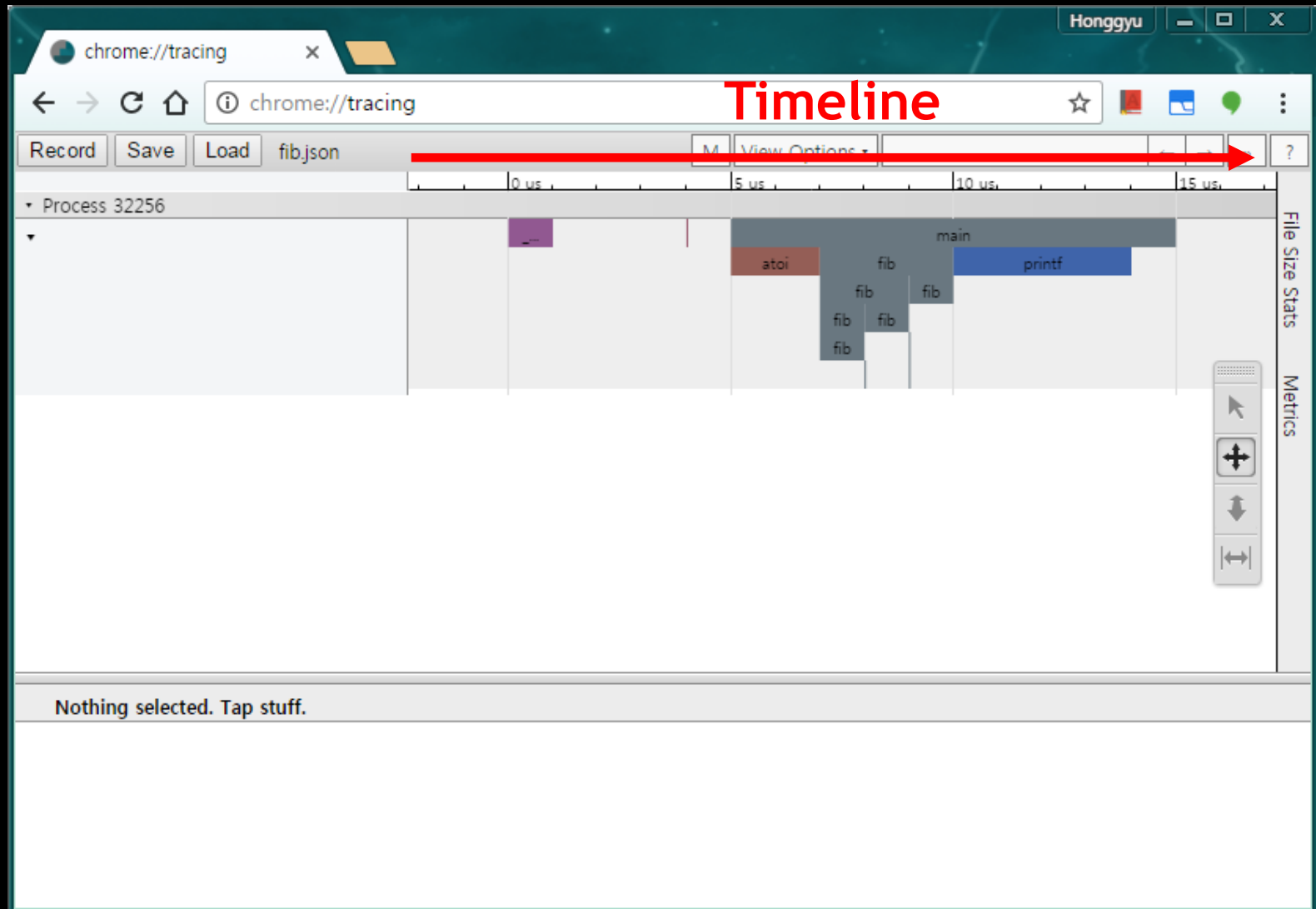
1. Open Chrome Browser
2. Load JSON file in **chrome://tracing**



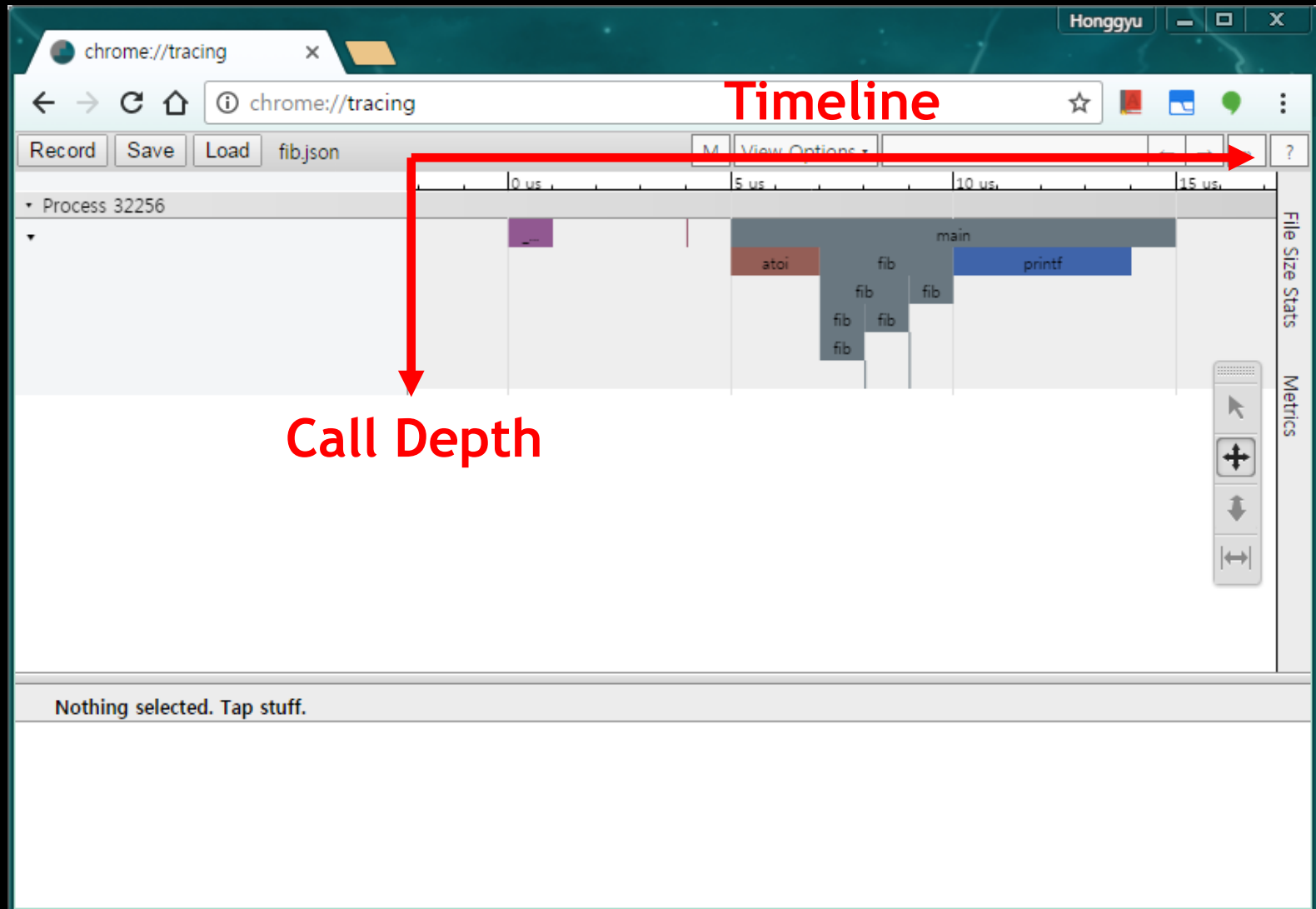
1. Open Chrome Browser
2. Load JSON file in **chrome://tracing**



1. Open Chrome Browser
2. Load JSON file in **chrome://tracing**



1. Open Chrome Browser
2. Load JSON file in **chrome://tracing**



chrome://tracing

Chrome | chrome://tracing

RecordSaveLoadView Options

Navigation

w/s Zoom in/out (+shift: faster)

a/d Pan left/right (+shift: faster)


→/shift-TAB Select previous event

←/TAB Select next event

Mouse Controls

click Select event


alt-mousewheel Zoom in/out

 **Select mode**


drag Box select

ctrl-click/drag Add events to the current selection


double click Select all events with same title

 **Pan mode**

drag Pan the view

 **Zoom mode**

drag Zoom in/out by dragging up/down

 **Timing mode**

drag Create or move markers

double click Set marker range to slice

General

1-4 Switch mouse mode

shift Hold for temporary select

space Hold for temporary pan

/ Search

enter Step through search results

f Zoom into selection

z/0 Reset zoom and pan

g/G Toggle 60hz grid

v Highlight VSync

h Toggle low/high details

m Mark current selection

P Select power samples over current selection interval

` Show or hide the scripting console

? Show help

Nothing selected. Tap st

JSON 파일을 HTML 로 변환

- "trace2html" 으로 .json 파일을 .html 파일로 변환 가능.
 - <https://github.com/catapult-project/catapult/blob/master/tracing/bin/trace2html>

```
$ trace2html trace-fib.json
```

JSON 파일을 HTML 로 변환

- "trace2html" 으로 .json 파일을 .html 파일로 변환 가능.
 - <https://github.com/catapult-project/catapult/blob/master/tracing/bin/trace2html>

```
$ trace2html trace-fib.json  
trace-fib.html
```

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

Tracing Pre-Built Binaries

(without -pg compilation)

GCC 의 컴파일 절차

Tracing Pre-Built Binaries

```
$ /usr/bin/gcc
```

Tracing Pre-Built Binaries

```
$ /usr/bin/gcc hello.c
```

Tracing Pre-Built Binaries

```
$ uftrace /usr/bin/gcc hello.c
```

Tracing Pre-Built Binaries

```
$ uftrace /usr/bin/gcc hello.c
```

```
uftrace: /home/honggyu/work/uftrace/cmd-record.c:1477:check_binary
```

```
ERROR: Can't find 'mcount' symbol in the '/usr/bin/gcc'.
```

```
It seems not to be compiled with -pg or -finstrument-functions flag  
which generates traceable code. Please check your binary file.
```


Tracing Pre-Built Binaries

```
$ uftrace /usr/bin/gcc hello.c
```

```
uftrace: /home/honggyu/work/uftrace/cmd-record.c:1477:check_binary
```

```
ERROR: Can't find 'mcount' symbol in the '/usr/bin/gcc'.
```

```
It seems not to be compiled with -pg or -finstrument-functions flag  
which generates traceable code. Please check your binary file.
```

```
$ uftrace --force /usr/bin/gcc hello.c
```

--force 옵션을 사용해
라이브러리 tracing 가능

Tracing Pre-Built Binaries

```
$ uftrace --force /usr/bin/gcc hello.c
```

```
# DURATION      TID      FUNCTION
    9.500 us [118164] | malloc();
    1.250 us [118164] | sbrk();
    0.573 us [118164] | malloc();
   12.070 us [118164] | memcpy();
           [118164] | _obstack_begin() {
    4.403 us [118164] |     malloc();
    6.510 us [118164] | } /* _obstack_begin */
    0.424 us [118164] | malloc();
    1.993 us [118164] | calloc();
    0.530 us [118164] | malloc();
    0.263 us [118164] | malloc();
    0.843 us [118164] | free();
    1.477 us [118164] | realloc();
    1.197 us [118164] | __fsetlocking();
    0.174 us [118164] | __fsetlocking();
    0.163 us [118164] | __fsetlocking();
           [118164] | setlocale() {
    0.446 us [118164] |     free();
    0.260 us [118164] |     free();
   59.964 us [118164] | } /* setlocale */
           [118164] | setlocale() {
    0.314 us [118164] |     free();
    0.177 us [118164] |     free();
    8.150 us [118164] | } /* setlocale */
   10.880 us [118164] | bindtextdomain();
    1.770 us [118164] | textdomain();
           [118164] | gettext() {
    0.324 us [118164] |     free();
    0.403 us [118164] |     free();
    0.313 us [118164] |     free();
    ...
```

--force

**Trace even if executable is
not instrumented**

Tracing Pre-Built Binaries

```
$ ufttrace --force -t 700us /usr/bin/gcc hello.c
```

#	DURATION	TID	FUNCTION
		[118394]	vfork() {
		[118405]	} /* vfork */
		[118405]	execv() {
536.841	us	[118394]	} /* vfork */
338.661	ms	[118394]	waitpid();
		[118394]	vfork() {
		[118406]	} /* vfork */
		[118406]	execvp() {
667.389	us	[118394]	} /* vfork */
99.625	ms	[118394]	waitpid();
		[118394]	vfork() {
		[118407]	} /* vfork */
		[118407]	execv() {
567.135	us	[118394]	} /* vfork */
		[118394]	waitpid() {
		[118407]	vfork() {
		[118408]	} /* vfork */
		[118408]	execvp() {
580.571	us	[118407]	} /* vfork */
		[118407]	waitpid() {
2.918	ms	[118408]	bfd_elf_size_dynamic_sections();
1.267	ms	[118408]	bfd_elf_size_dynsym_hash_dynstr();
120.809	ms	[118407]	} /* waitpid */
199.775	ms	[118394]	} /* waitpid */

-t TIME, --time-filter=TIME

Do not show functions which run under the time threshold. If some functions explicitly have the 'trace' trigger applied, those are always traced regardless of execution time.

Tracing Pre-Built Binaries

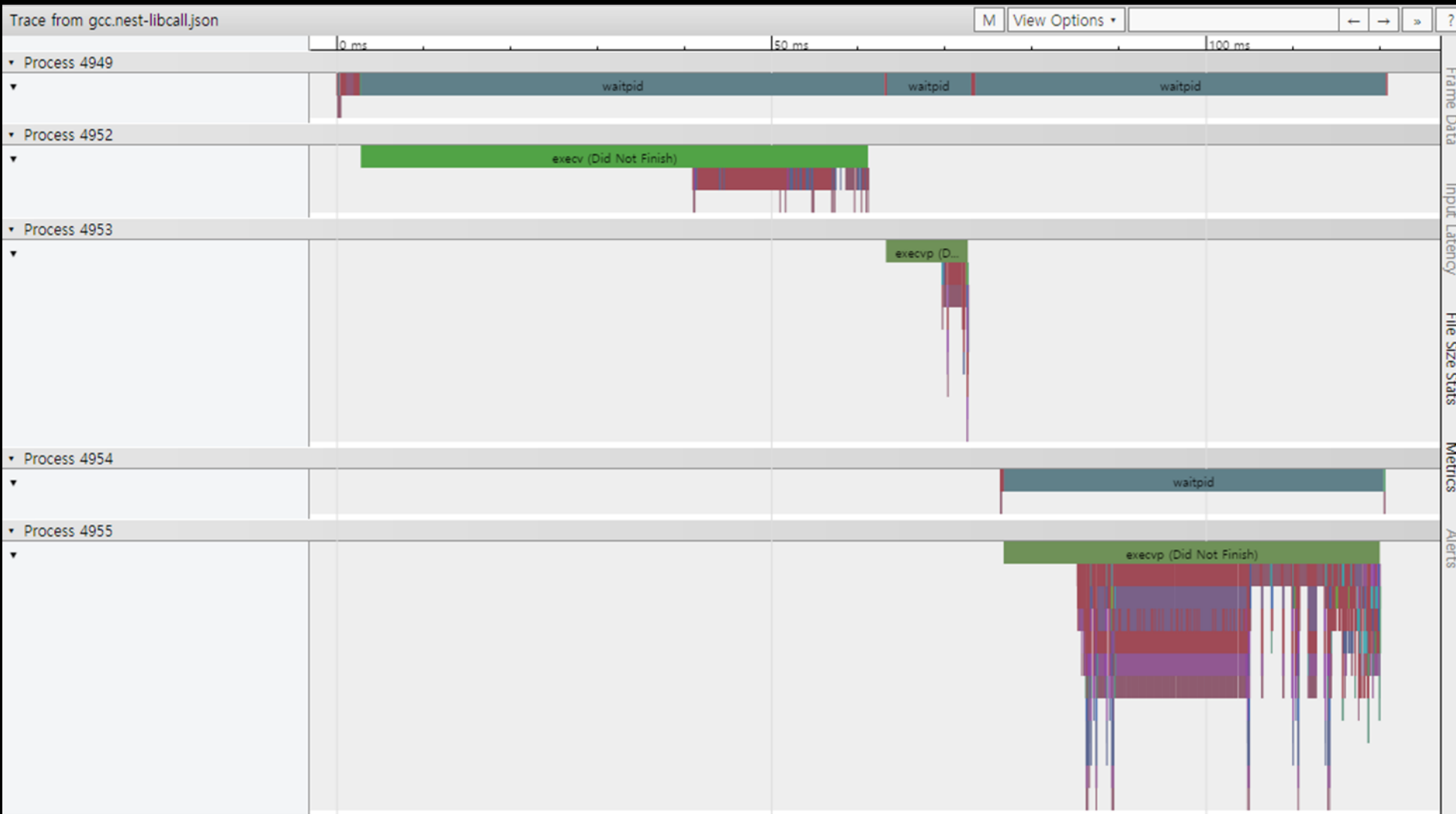
```
$ ufttrace --force -t 700us --auto-args /usr/bin/gcc hello.c
```

```
# DURATION      TID      FUNCTION
      [118394] | vfork() {
      [118405] | } = 0; /* vfork */
      [118405] | execv("/usr/lib/gcc/x86_64-linux-gnu/5/cc1") {
536.841 us [118394] | } = 0x1ce85; /* vfork */
338.661 ms [118394] | waitpid(0x1ce85, 0xa6d610, 0) = 0x1ce85;
      [118394] | vfork() {
      [118406] | } = 0; /* vfork */
      [118406] | execvp("as") {
667.389 us [118394] | } = 0x1ce86; /* vfork */
  99.625 ms [118394] | waitpid(0x1ce86, 0xa6d7b0, 0) = 0x1ce86;
      [118394] | vfork() {
      [118407] | } = 0; /* vfork */
      [118407] | execv("/usr/lib/gcc/x86_64-linux-gnu/5/collect2") {
567.135 us [118394] | } = 0x1ce87; /* vfork */
      [118394] | waitpid(0x1ce87, 0xa74ae0, 0) {
      [118407] | vfork() {
      [118408] | } = 0; /* vfork */
      [118408] | execvp("/usr/bin/ld") {
580.571 us [118407] | } = 0x1ce88; /* vfork */
      [118407] | waitpid(0x1ce88, 0x8a3240, 0) {
   2.918 ms [118408] | bfd_elf_size_dynamic_sections();
   1.267 ms [118408] | bfd_elf_size_dynsym_hash_dynstr();
120.809 ms [118407] | } = 0x1ce88; /* waitpid */
199.775 ms [118394] | } = 0x1ce87; /* waitpid */
```

Automatically record arguments
and return values of known
functions.

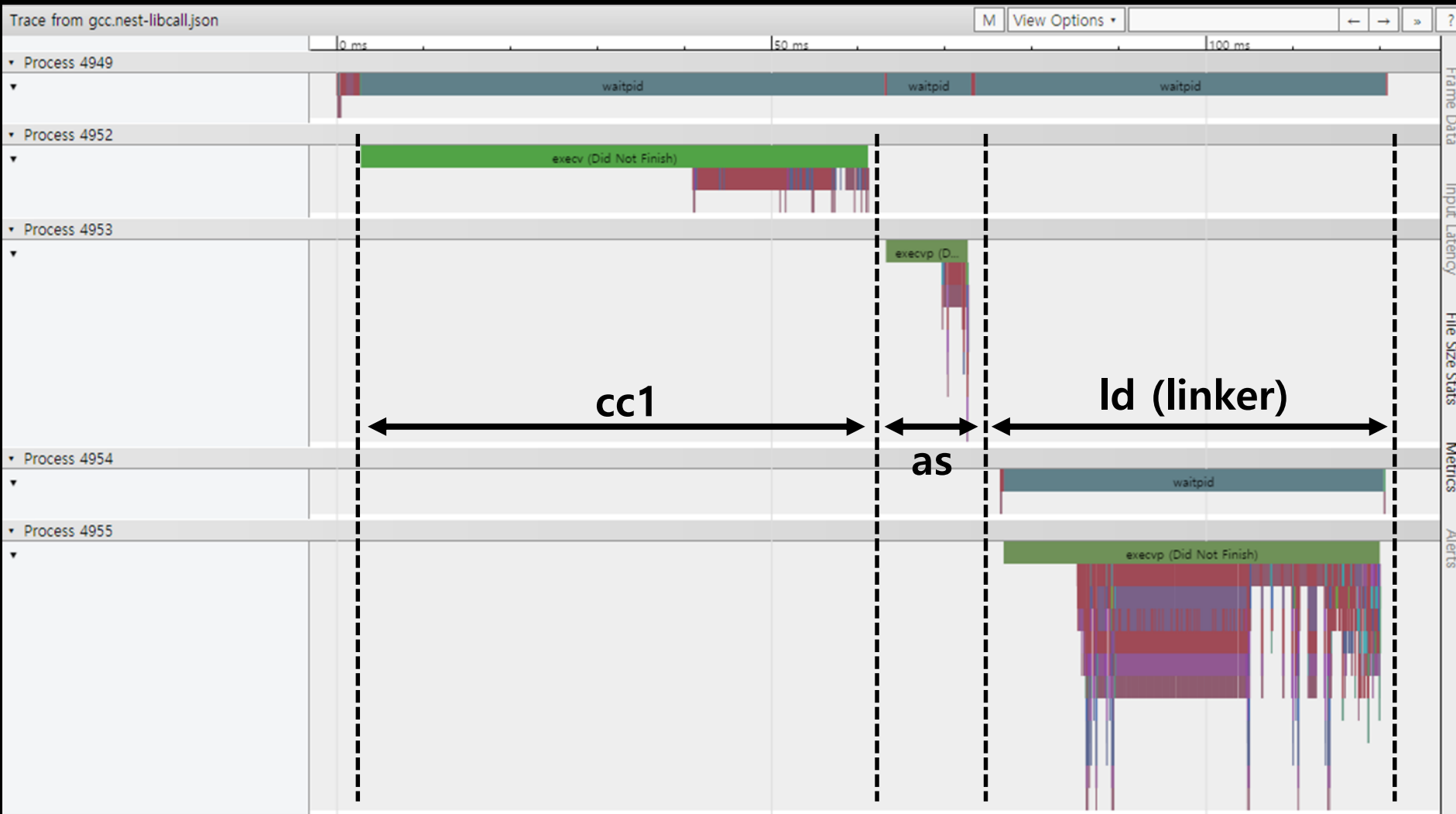
Tracing Pre-Built Binaries

```
$ uftrace dump --chrome
```



Tracing Pre-Built Binaries

```
$ uftrace dump --chrome
```



C++ Case Study with uftrace

uftrace 를 활용한 C++ 내부에 대한 분석

std::endl

std::endl 을 사용하지 말아야 하는 이유

std::endl

- **std::endl** 은 내부에서 어떤 일을 하는가?

```
std::cout << std::endl;
```

std::endl

- std::endl 은 내부에서 어떤 일을 하는가?

```
std::cout << std::endl;
```



```
std::cout << '\n' << std::flush;
```

```
$ cat test-endl.cpp
#include <iostream>
#include <vector>
```

```
int main()
{
    std::vector<int> v = { 10, 20, 30 };
    for (auto a : v)
        std::cout << a << std::endl;
}
```

```
$ g++ -O2 -pg test-endl.cpp
```

```
$ uftrace a.out
```

```
10
```

```
20
```

```
30
```

```
$ uftrace a.out
```

```
10
```

```
20
```

```
30
```

std::endl 호출시 반복된 flush 발생

#	DURATION	TID	FUNCTION
		[122233]	_GLOBAL__sub_I_main() {
156.463	us	[122233]	std::ios_base::Init::Init();
0.426	us	[122233]	__cxa_atexit();
164.050	us	[122233]	} /* _GLOBAL__sub_I_main */
		[122233]	main() {
2.336	us	[122233]	operator new();
21.507	us	[122233]	std::basic_ostream::operator<<();
15.691	us	[122233]	std::basic_ostream::put();
2.920	us	[122233]	std::basic_ostream::flush();
0.907	us	[122233]	std::basic_ostream::operator<<();
2.394	us	[122233]	std::basic_ostream::put();
0.344	us	[122233]	std::basic_ostream::flush();
0.313	us	[122233]	std::basic_ostream::operator<<();
2.064	us	[122233]	std::basic_ostream::put();
0.234	us	[122233]	std::basic_ostream::flush();
3.050	us	[122233]	operator delete();
58.105	us	[122233]	} = 0; /* main */
3.837	us	[122233]	std::ios_base::Init::~~Init();

```
$ cat test-endl.cpp
#include <iostream>
#include <vector>
```

```
int main()
{
    std::vector<int> v = { 10, 20, 30 };
    for (auto a : v)
        std::cout << a << '\n';
}
```

```
$ g++ -O2 -pg test-endl.cpp
```

```
$ uftrace a.out
```

```
10
```

```
20
```

```
30
```

```
$ uftrace a.out
```

```
10
```

```
20
```

```
30
```

불필요한 flush 없음

#	DURATION	TID	FUNCTION
		[122346]	_GLOBAL__sub_I_main() {
170.023	us	[122346]	std::ios_base::Init::Init();
0.380	us	[122346]	__cxa_atexit();
178.013	us	[122346]	} /* _GLOBAL__sub_I_main */
		[122346]	main() {
2.184	us	[122346]	operator new();
14.537	us	[122346]	std::basic_ostream::operator<<();
16.204	us	[122346]	std::__ostream_insert();
0.720	us	[122346]	std::basic_ostream::operator<<();
2.430	us	[122346]	std::__ostream_insert();
0.353	us	[122346]	std::basic_ostream::operator<<();
2.150	us	[122346]	std::__ostream_insert();
3.170	us	[122346]	operator delete();
46.781	us	[122346]	} = 0; /* main */
5.284	us	[122346]	std::ios_base::Init::~~Init();

new[] and delete[]

new[] 가 반환하는 주소는 어디인가?

new and delete

```
$ cat new-delete.cc
class Point {
    char buf[10];
public:
    Point() {}
    ~Point() {}
};

void addr_of_p(void* p) {}

int main()
{
    Point* p1 = new Point;
    addr_of_p(p1);
    delete p1;
}
```

new and delete

```
$ cat new-delete.cc
```

```
class Point {  
    char buf[10];  
public:  
    Point() {}  
    ~Point() {}  
};
```

```
void addr_of_p(void* p) {}
```

```
int main()  
{  
    Point* p1 = new Point;  
    addr_of_p(p1);  
    delete p1;  
}
```

```
$ uftrace -a --nest-libcall \  
-f none a.out
```

new and delete

```
$ cat new-delete.cc
```

```
class Point {  
    char buf[10];  
public:  
    Point() {}  
    ~Point() {}  
};  
  
void addr_of_p(void* p) {}  
  
int main()  
{  
    Point* p1 = new Point;  
    addr_of_p(p1);  
    delete p1;  
}
```

```
$ uftrace -a --nest-libcall \  
-f none a.out
```

```
main() {  
    operator new(10) {  
        malloc(10) = 0x262afd0;  
    } = 0x262afd0; /* operator new */  
    Point::Point(0x262afd0);  
    addr_of_p(0x262afd0);  
    Point::~~Point(0x262afd0);  
    operator delete(0x262afd0) {  
        free(0x262afd0);  
    } /* operator delete */  
} = 0; /* main */
```

new[] and delete[]

```
$ cat array-new-delete.cc
class Point {
    char buf[10];
public:
    Point() {}
    ~Point() {}
};

void addr_of_p(void* p) {}

int main()
{
    Point* p2 = new Point[3];
    addr_of_p(p2);
    delete[] p2;
}
```

new[] and delete[]

```
$ cat array-new-delete.cc      $ uftrace -a --nest-libcall \
class Point {                  -f none a.out
    char buf[10];
public:
    Point() {}
    ~Point() {}
};

void addr_of_p(void* p) {}

int main()
{
    Point* p2 = new Point[3];
    addr_of_p(p2);
    delete[] p2;
}
```

new[] and delete[]

```
$ cat array-new-delete.cc
class Point {
    char buf[10];
public:
    Point() {}
    ~Point() {}
};


void addr_of_p(void* p) {}

int main()
{
    Point* p2 = new Point[3];
    addr_of_p(p2);
    delete[] p2;
}
```

```
$ ufttrace -a --nest-libcall \
-f none a.out
main() {
    operator new[](38) {
        operator new(38) {
            malloc(38) = 0xd7a020;
        } = 0xd7a020; /* operator new */
    } = 0xd7a020; /* operator new[] */
    Point::Point(0xd7a028);
    Point::Point(0xd7a032);
    Point::Point(0xd7a03c);
    addr_of_p(0xd7a028);
    Point::~~Point(0xd7a03c);
    Point::~~Point(0xd7a032);
    Point::~~Point(0xd7a028);
    operator delete[](0xd7a020) {
        operator delete(0xd7a020) {
            free(0xd7a020);
        } /* operator delete */
    } /* operator delete[] */
} = 0; /* main */
```

new[] and delete[]

10 바이트 크기의 객체 3개를 할당했는데 왜 38 바이트 할당을 요청할까?



```
$ cat array-new-delete.cc
class Point {
    char buf[10];
public:
    Point() {}
    ~Point() {}
};

void addr_of_p(void* p) {}

int main()
{
    Point* p2 = new Point[3];
    addr_of_p(p2);
    delete[] p2;
}
```

```
$ ufttrace -a --nest-libcall \
-f none a.out

main() {
    operator new[](38) {
        operator new(38) {
            malloc(38) = 0xd7a020;
        } = 0xd7a020; /* operator new */
    } = 0xd7a020; /* operator new[] */
    Point::Point(0xd7a028);
    Point::Point(0xd7a032);
    Point::Point(0xd7a03c);
    addr_of_p(0xd7a028);
    Point::~~Point(0xd7a03c);
    Point::~~Point(0xd7a032);
    Point::~~Point(0xd7a028);
    operator delete[](0xd7a020) {
        operator delete(0xd7a020) {
            free(0xd7a020);
        } /* operator delete */
    } /* operator delete[] */
} = 0; /* main */
```


new[] and delete[]

10 바이트 크기의 객체 3개를 할당했는데 왜 38 바이트 할당을 요청할까?

```
$ cat array-new-delete.cc
class Point {
    char buf[10];
public:
    Point() {}
    ~Point() {}
};

void addr_of_p(void* p) {}

int main()
{
    Point* p2 = new Point[3];
    addr_of_p(p2);
    delete[] p2;
}
```

왜 실제 메모리가 할당된 주소보다 8이 클까?

```
$ ufttrace -a --nest-libcall \
-f none a.out

main() {
    operator new[](38) {
        operator new(38) {
            malloc(38) = 0xd7a020;
        } = 0xd7a020; /* operator new */
    } = 0xd7a020; /* operator new[] */
    Point::Point(0xd7a028);
    Point::Point(0xd7a032);
    Point::Point(0xd7a03c);
    addr_of_p(0xd7a028);
    Point::~~Point(0xd7a03c);
    Point::~~Point(0xd7a032);
    Point::~~Point(0xd7a028);
    operator delete[](0xd7a020) {
        operator delete(0xd7a020) {
            free(0xd7a020);
        } /* operator delete */
    } /* operator delete[] */
} = 0; /* main */
```

new[] and delete[]

```
$ cat array-new-delete.cc
```

```
class Point {  
    char buf[10];  
public:  
    Point() {}  
    ~Point() {}  
};  
  
void addr_of_p(void* p) {}  
  
int main()  
{  
    Point* p2 = new Point[3];  
    addr_of_p(p2);  
    delete[] p2;  
}
```

```
$ cat wrong-array-new-delete.cc
```

```
class Point {  
    char buf[10];  
public:  
    Point() {}  
    ~Point() {}  
};  
  
void addr_of_p(void* p) {}  
  
int main()  
{  
    Point* p2 = new Point[3];  
    addr_of_p(p2);  
    delete[] p2;  
}
```

new[] and deleteX

```
$ cat array-new-delete.cc
```

```
class Point {
    char buf[10];
public:
    Point() {}
    ~Point() {}
};

void addr_of_p(void* p) {}

int main()
{
    Point* p2 = new Point[3];
    addr_of_p(p2);
    delete[] p2;
}
```

```
$ cat wrong-array-new-delete.cc
```

```
class Point {
    char buf[10];
public:
    Point() {}
    ~Point() {}
};

void addr_of_p(void* p) {}

int main()
{
    Point* p2 = new Point[3];
    addr_of_p(p2);
    // delete[] p2;
    delete p2;
}
```

new[] and delete

```
$ uftrace -a --nest-libcall wrong-array-new-delete
```

new[] and delete

```
$ uftrace -a --nest-libcall wrong-array-new-delete  
*** Error in `wrong-array-new-delete': munmap_chunk(): invalid pointer: 0x1af0aa8 ***  
process crashed by signal 11: Segmentation fault (si_code: 128)  
child terminated by signal: 11: Segmentation fault
```

new[] and delete

```
$ ufttrace -a --nest-libcall wrong-array-new-delete
*** Error in `wrong-array-new-delete': munmap_chunk(): invalid pointer: 0x1af0aa8 ***
process crashed by signal 11: Segmentation fault (si_code: 128)
child terminated by signal: 11: Segmentation fault
```

```
# DURATION      TID      FUNCTION
    [ 79033] | main() {
    [ 79033] |   operator new[](38) {
    [ 79033] |     operator new(38) {
0.933 us [ 79033] |       malloc(38) = 0x1af0aa0;
4.687 us [ 79033] |       } = 0x1af0aa0; /* operator new */
12.374 us [ 79033] |     } = 0x1af0aa0; /* operator new[] */
0.460 us [ 79033] |   Point::Point(0x1af0aa8);
0.210 us [ 79033] |   Point::Point(0x1af0ab2);
0.207 us [ 79033] |   Point::Point(0x1af0abc);
0.227 us [ 79033] |   addr_of_p(0x1af0aa8);
0.230 us [ 79033] |   Point::~~Point(0x1af0aa8);
    [ 79033] |   operator delete(0x1af0aa8) {
    [ 79033] |     free(0x1af0aa8) {
    [ 79033] |       /* linux:task-exit */
```

```
ufttrace stopped tracing with remaining functions
```

```
=====
```

```
task: 79033
```

```
[2] free
```

```
[1] operator delete
```

```
[0] main
```

new[] and delete

```
$ ufttrace -a --nest-libcall wrong-array-new-delete
*** Error in `wrong-array-new-delete': munmap_chunk(): invalid pointer: 0x1af0aa8 ***
process crashed by signal 11: Segmentation fault (si_code: 128)
child terminated by signal: 11: Segmentation fault
```

```
# DURATION      TID      FUNCTION
[ 79033] | main() {
[ 79033] |   operator new[](38) {
[ 79033] |     operator new(38) {
0.933 us [ 79033] |       malloc(38) = 0x1af0aa0;
4.687 us [ 79033] |     } = 0x1af0aa0; /* operator new */
12.374 us [ 79033] |   } = 0x1af0aa0; /* operator new[] */
0.460 us [ 79033] |   Point::Point(0x1af0aa8);
0.210 us [ 79033] |   Point::Point(0x1af0ab2);
0.207 us [ 79033] |   Point::Point(0x1af0abc);
0.227 us [ 79033] |   addr_of_p(0x1af0aa8);
0.230 us [ 79033] |   Point::~~Point(0x1af0aa8);
[ 79033] |   operator delete(0x1af0aa8) {
[ 79033] |     free(0x1af0aa8) {
[ 79033] |       /* linux:task-exit */
```

**실제 malloc 으로 얻은
주소와 free 를 요청하는
주소가 달라서 segfault**

```
ufttrace stopped tracing with remaining functions
```

```
=====
```

```
task: 79033
```

```
[2] free
```

```
[1] operator delete
```

```
[0] main
```

new[] and delete

```
$ uftrace -a --nest-libcall wrong-array-new-delete
*** Error in `wrong-array-new-delete': munmap_chunk(): invalid pointer: 0x1af0aa8 ***
process crashed by signal 11: Segmentation fault (si_code: 128)
child terminated by signal: 11: Segmentation fault
```

```
# DURATION      TID      FUNCTION
    [ 79033] | main() {
    [ 79033] |   operator new[](38) {
    [ 79033] |     operator new(38) {
0.933 us [ 79033] |       malloc(38) = 0x1af0aa0;
4.687 us [ 79033] |       } = 0x1af0aa0; /* operator new */
12.374 us [ 79033] |     } = 0x1af0aa0; /* operator new[] */
0.460 us [ 79033] |   Point::Point(0x1af0aa8);
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0.207 us [ 79033] |   Point::Point(0x1af0abc);
0.227 us [ 79033] |   addr_of_p(0x1af0aa8);
0.230 us [ 79033] |   Point::~~Point(0x1af0aa8);
    [ 79033] |   operator delete(0x1af0aa8) {
    [ 79033] |     free(0x1af0aa8) {
    [ 79033] |       /* linux:task-exit */
```

**실제 malloc 으로 얻은
주소와 free 를 요청하는
주소가 달라서 segfault**

```
uftrace stopped tracing with remaining functions
=====
```

```
task: 79033
[2] free
[1] operator delete
[0] main
```

**segfault 로 프로그램이 비정상
종료할 때까지의 경로도 확인 가능!**

new[] and delete[]

```
Point* p = new Point[3]
```

new[] and delete[]

```
Point* p = new Point[3]
```

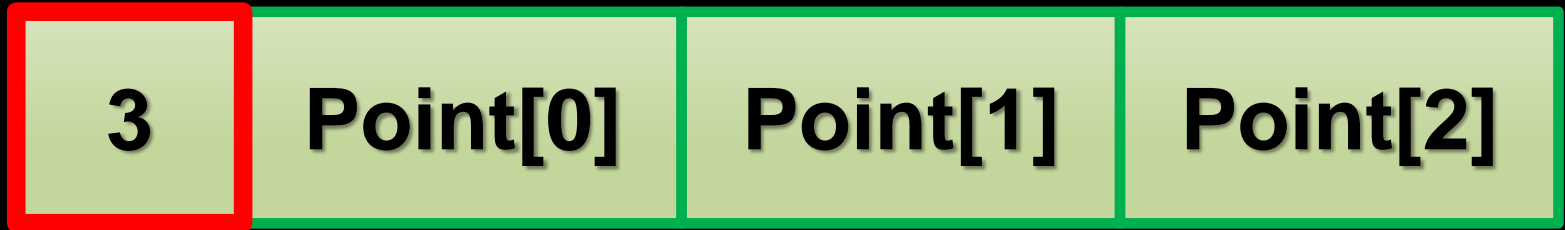
Point[0]

Point[1]

Point[2]

new[] and delete[]

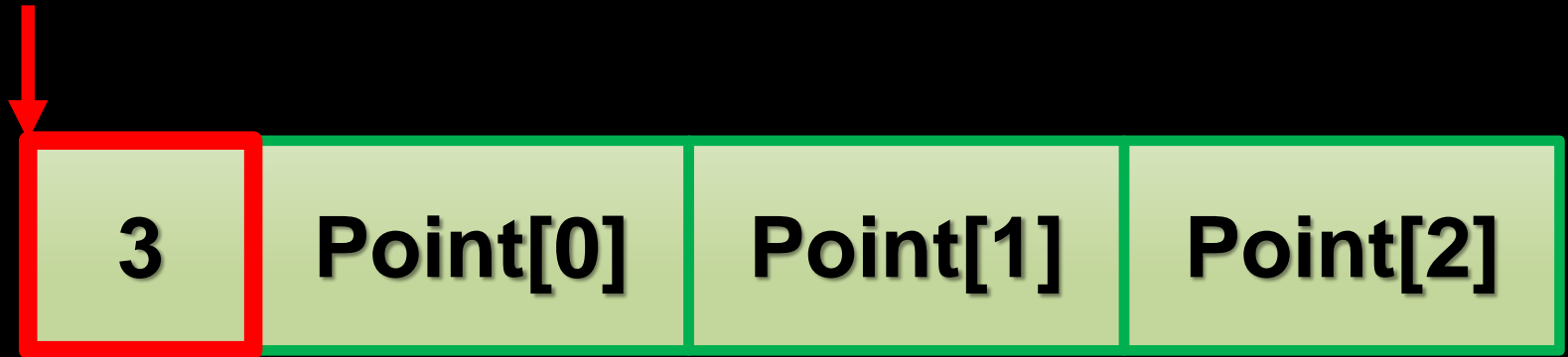
```
Point* p = new Point[3]
```



new[] and delete[]

```
Point* p = new Point[3]
```

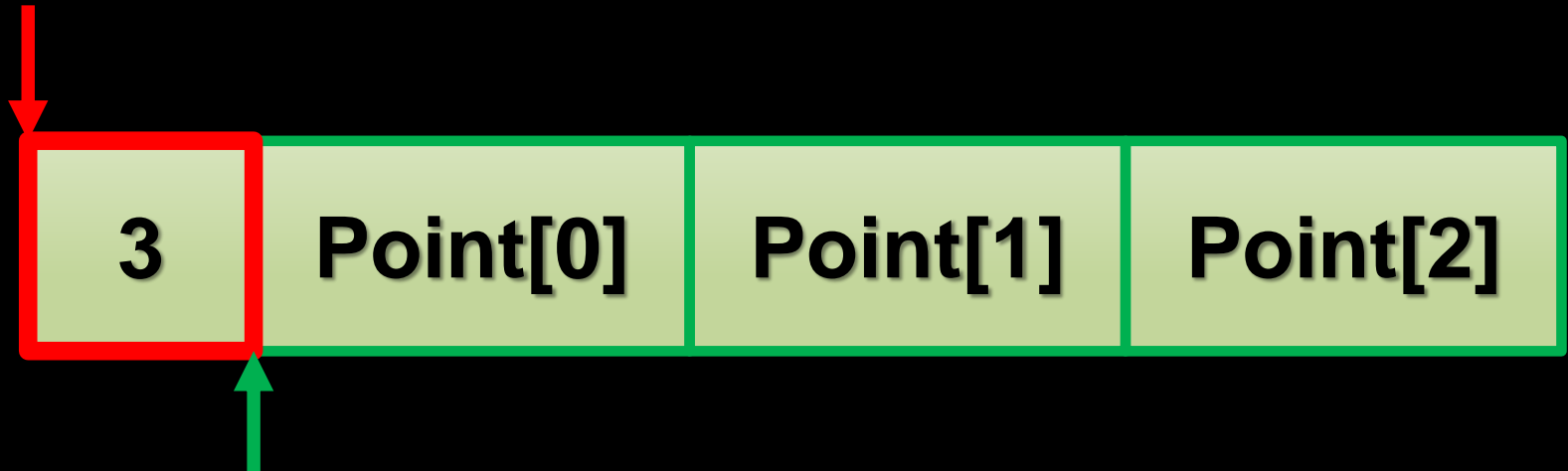
실제 내부적으로 할당하는 메모리 공간의 시작 주소



new[] and delete[]

```
Point* p = new Point[3]
```

실제 내부적으로 할당하는 메모리 공간의 시작 주소

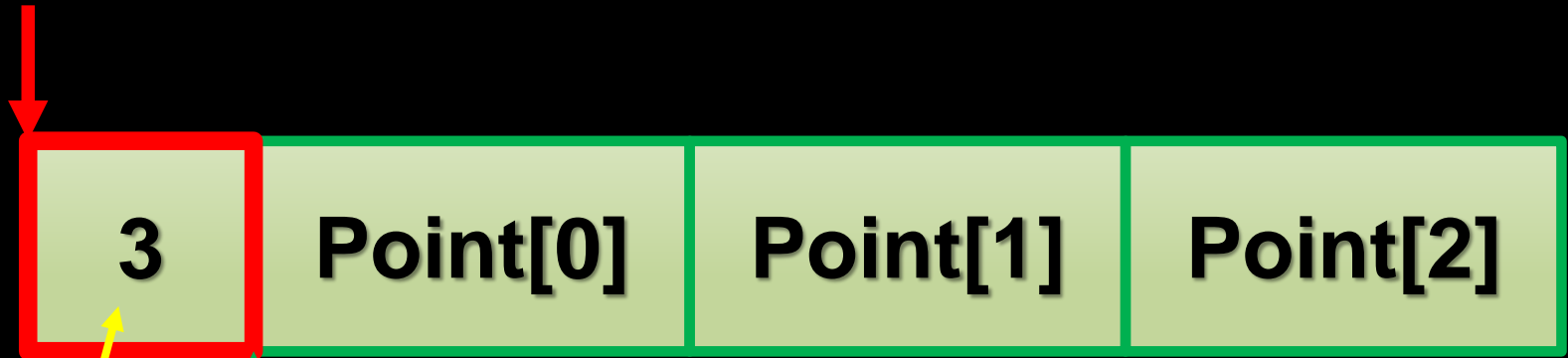


new[] 가 반환하는 첫번째 객체의 시작 주소

new[] and delete[]

```
Point* p = new Point[3]
```

실제 내부적으로 할당하는 메모리 공간의 시작 주소



new[] 가 반환하는 첫번째 객체의 시작 주소

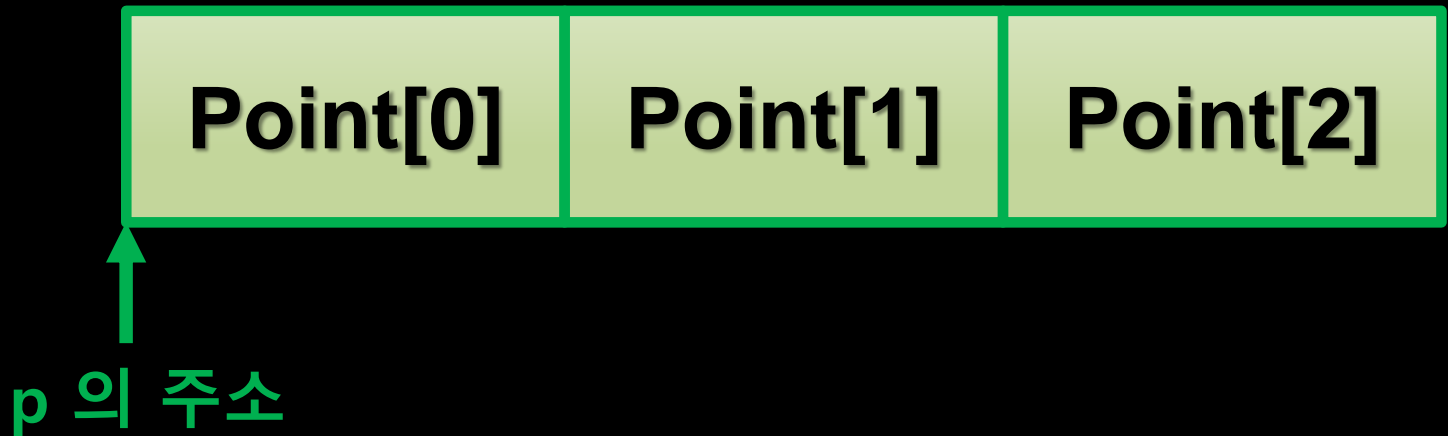
할당된 객체의 수

new[] and delete[]

```
delete[] p
```

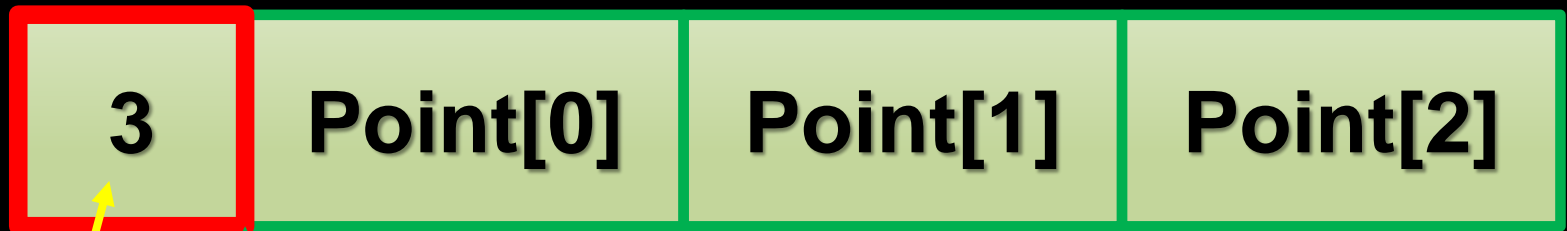
new[] and delete[]

```
delete[] p
```



new[] and delete[]

```
delete[] p
```

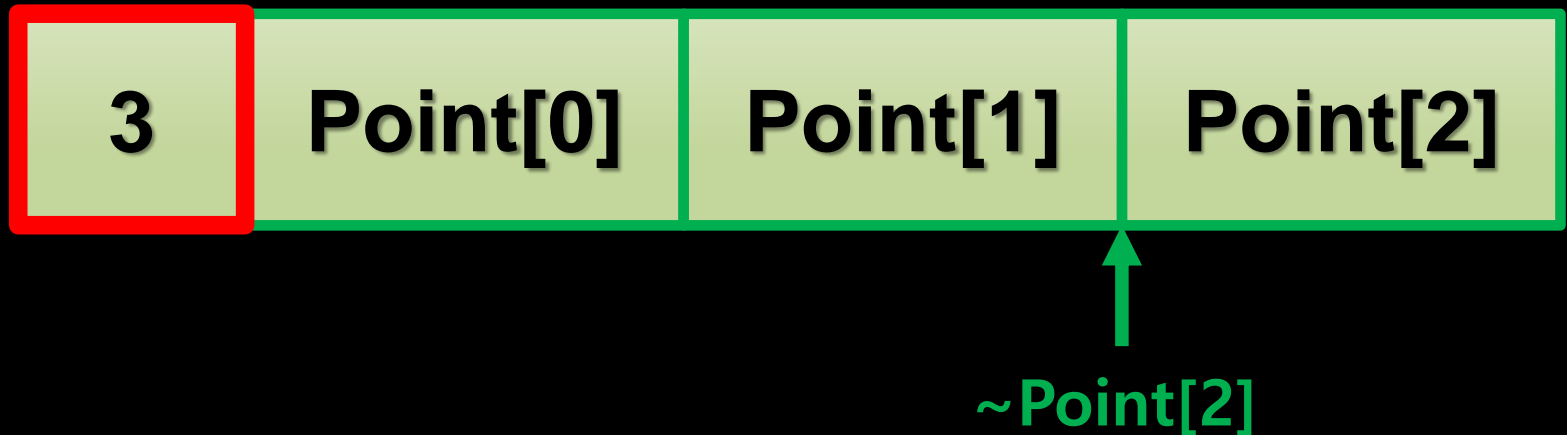


p의 주소

할당된 객체의 수

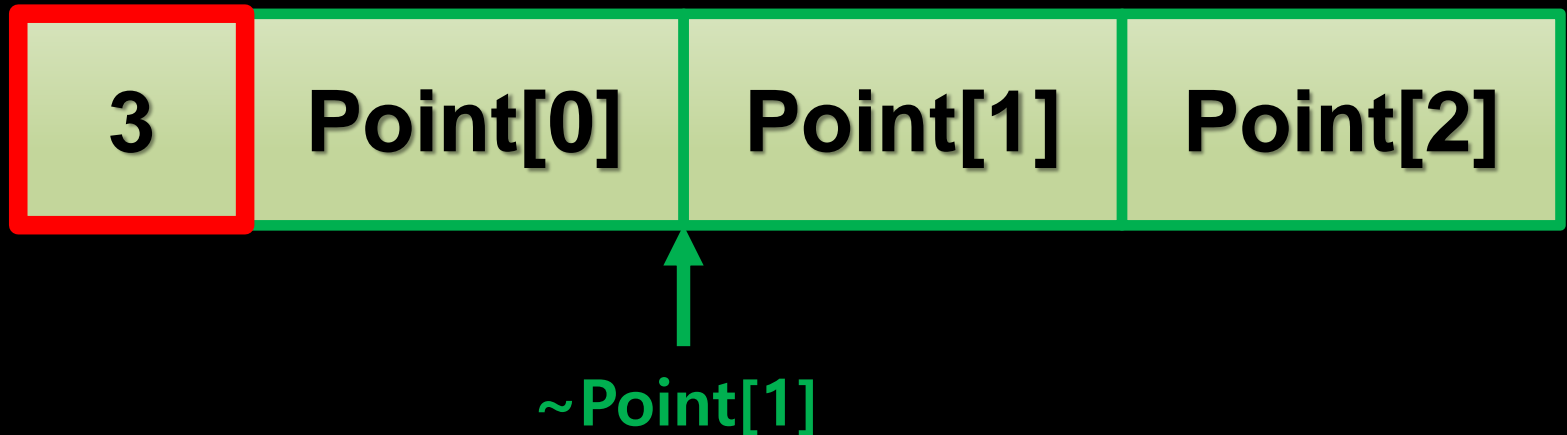
new[] and delete[]

```
delete[] p
```



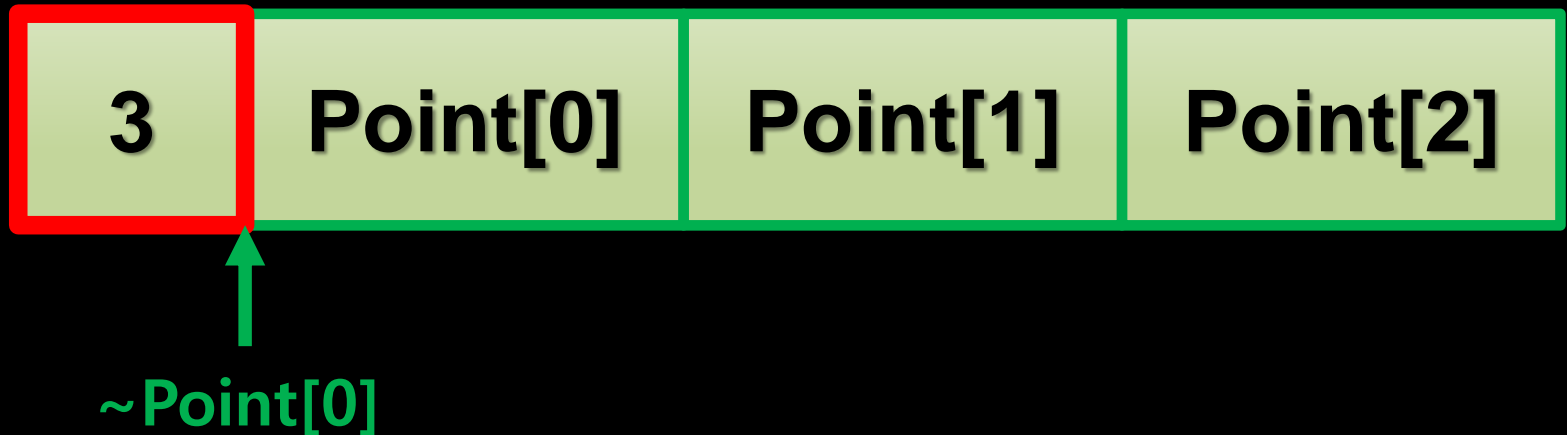
new[] and delete[]

```
delete[] p
```



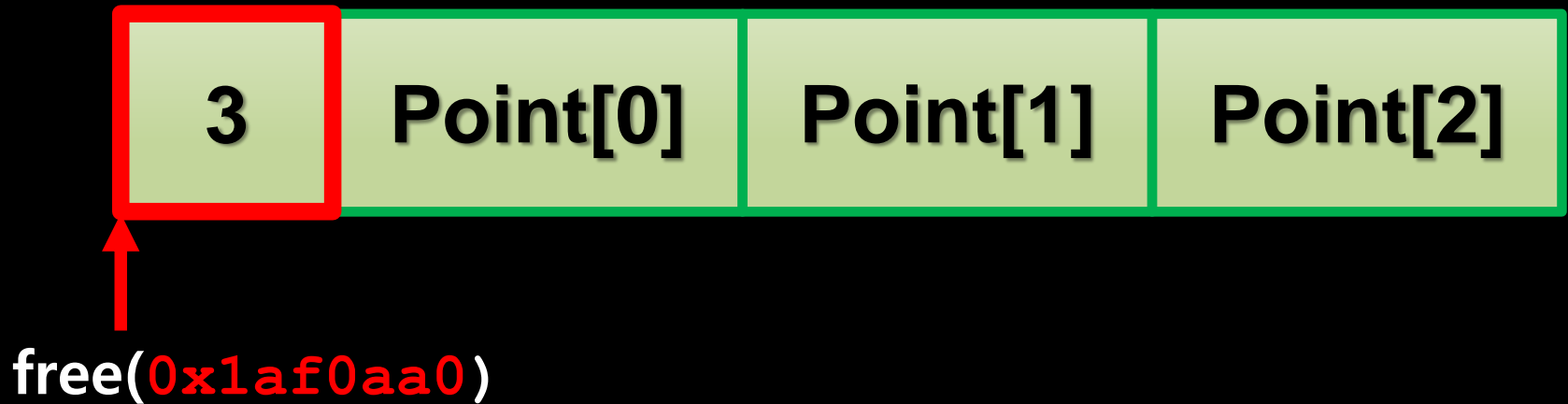
new[] and delete[]

`delete[] p`




`new[]` and `delete[]`

```
delete[] p
```



new[] and delete[]

```
delete[] p
```




```
free(0x1af0aa0)
```

new[] and delete[]

```
delete[] p
```

정상적인 메모리 해제


free(0x1af0aa0)

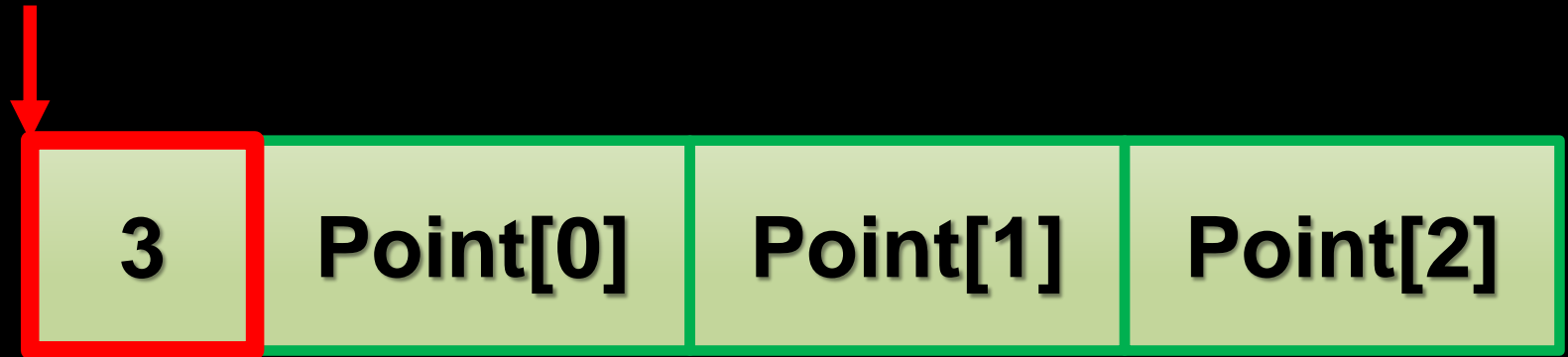
new[] and delete[]

```
main() {
    operator new[](38) {
        operator new(38) {
            malloc(38) = 0xd7a020;
        } = 0xd7a020; /* operator new */
    } = 0xd7a020; /* operator new[] */
    Point::Point(0xd7a028);           Point[0]
    Point::Point(0xd7a032);           Point[1]
    Point::Point(0xd7a03c);           Point[2]
    addr_of_p(0xd7a028);
    Point::~~Point(0xd7a03c);         ~Point[2]
    Point::~~Point(0xd7a032);         ~Point[1]
    Point::~~Point(0xd7a028);         ~Point[0]
    operator delete[](0xd7a020) {
        operator delete(0xd7a020) {
            free(0xd7a020);
        } /* operator delete */
    } /* operator delete[] */
} = 0; /* main */
```


new[] and delete[]

```
Point* p = new Point[3]
```

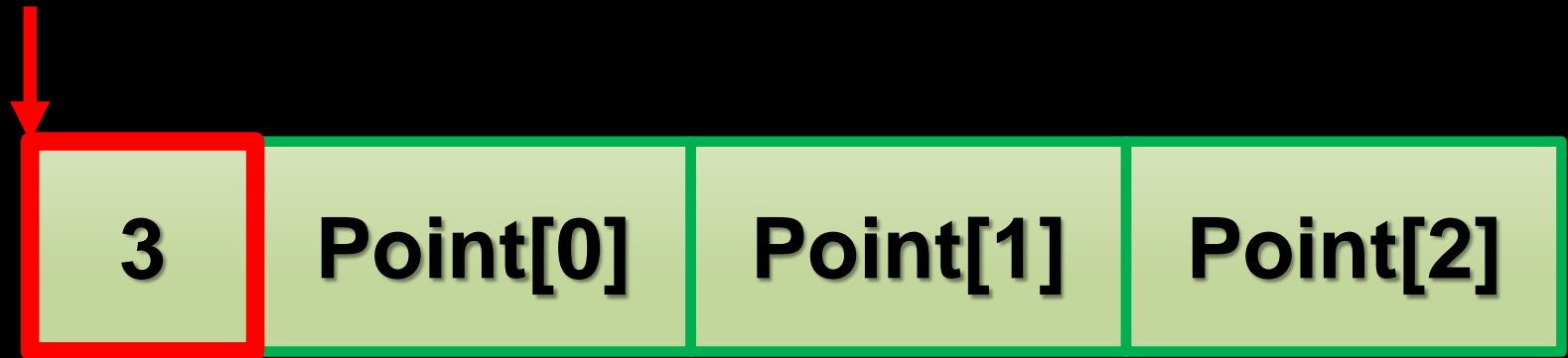
```
malloc(38) = 0x1af0aa0;
```



new[] and deleteX

```
Point* p = new Point[3]  
delete p;
```

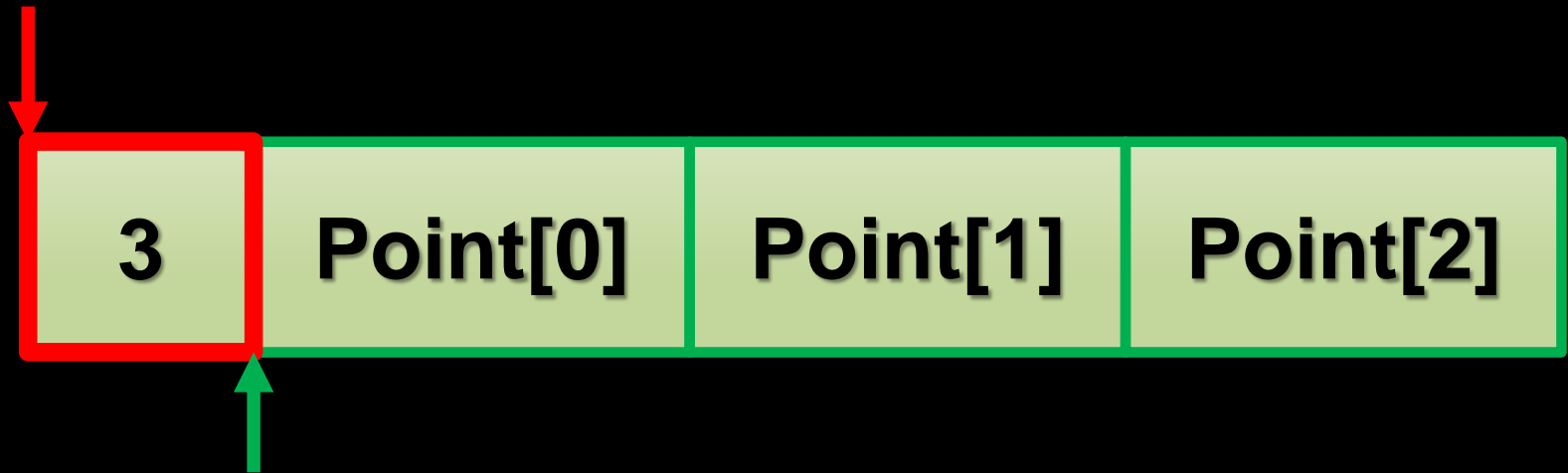
```
malloc(38) = 0x1af0aa0;
```



new[] and deleteX

```
Point* p = new Point[3]  
delete p;
```

malloc(38) = 0x1af0aa0;

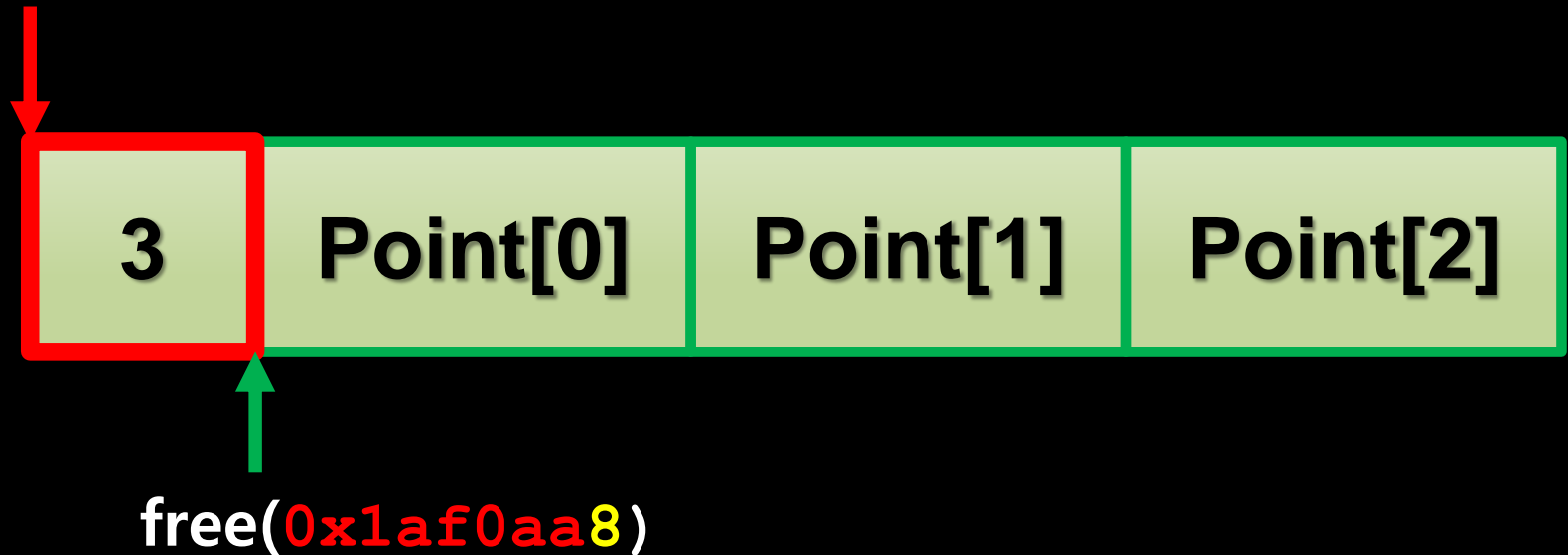


free(0x1af0aa8)

new[] and deleteX

```
Point* p = new Point[3]  
delete p;
```

```
malloc(38) = 0x1af0aa0;
```



할당되지 않은 주소에 대한 메모리 해제 요청

Zero-Cost Abstractions

Abstractions have cost, but mostly zero in C++!

std::unique_ptr

new / delete 와 성능 차이가 있을까?

new and delete

```
$ cat new-delete.cc  
int main()  
{  
    int* p = new int;  
    delete p;  
}
```

new and delete

```
$ cat new-delete.cc
```

```
int main()
{
    int* p = new int;
    delete p;
}
```

```
$ g++ -pg -g -O2 new-delete.cc
```


new and delete

```
$ cat new-delete.cc
```

```
int main()
{
    int* p = new int;
    delete p;
}
```

```
$ g++ -pg -g -O2 new-delete.cc
```

```
$ uftrace -a --nest-libcall a.out
```

#	DURATION	TID	FUNCTION
		[165267]	main() {
		[165267]	operator new(4) {
0.976 us		[165267]	malloc(4) = 0x21ceaa0;
7.847 us		[165267]	} = 0x21ceaa0; /* operator new */
		[165267]	operator delete(0x21ceaa0) {
1.807 us		[165267]	free(0x21ceaa0);
5.261 us		[165267]	} /* operator delete */
18.154 us		[165267]	} = 0; /* main */

std::unique_ptr

```
$ cat unique_ptr.cc
#include <memory>
int main()
{
    std::unique_ptr<int> p(new int);
}
```

std::unique_ptr

```
$ cat unique_ptr.cc
```

```
#include <memory>
```

```
int main()
```

```
{
```

```
    std::unique_ptr<int> p(new int);
```

```
}
```

```
$ g++ -std=c++11 -pg -g -O2 unique_ptr.cc
```

std::unique_ptr

```
$ cat unique_ptr.cc
```

```
#include <memory>
```

```
int main()
```

```
{
```

```
    std::unique_ptr<int> p(new int);
```

```
}
```

```
$ g++ -std=c++11 -pg -g -O2 unique_ptr.cc
```

```
$ uftrace -a --nest-libcall a.out
```

#	DURATION	TID	FUNCTION
		[165318]	main() {
		[165318]	operator new(4) {
1.076 us		[165318]	malloc(4) = 0x1d7b290;
7.824 us		[165318]	} = 0x1d7b290; /* operator new */
		[165318]	operator delete(0x1d7b290) {
1.716 us		[165318]	free(0x1d7b290);
5.097 us		[165318]	} /* operator delete */
18.260 us		[165318]	} = 0; /* main */

std::unique_ptr

```
$ cat unique_ptr.cc
```

```
#include <memory>
```

```
int main()
```

```
{
```

```
    std::unique_ptr<int> p(new int);
```

```
}
```

```
$ g++ -std=c++11 -pg -g -O2 unique_ptr.cc
```

```
$ uftrace -a --nest-libcall a.out
```

```
# DURATION      TID      FUNCTION
      [165318] | main() {
      [165318] |   operator new(4) {
1.076 us [165318] |     malloc(4) = 0x1d7b290;
7.824 us [165318] |   } = 0x1d7b290; /* operator new */
      [165318] |   operator delete(0x1d7b290) {
1.716 us [165318] |     free(0x1d7b290);
5.097 us [165318] |   } /* operator delete */
18.260 us [165318] | } = 0; /* main */
```

**new 와 delete 를 직접
사용한 경우와 동일함**

#	DURATION	TID	FUNCTION
		[168276]	main() {
		[168276]	operator new (4) {
1.094 us		[168276]	malloc (4) = 0xbdbb40;
8.114 us		[168276]	} = 0xbdbb40; /* operator new */
		[168276]	std::unique_ptr::unique_ptr(0x7ffded6fd110, 0xbdbb40) {
		[168276]	std::tuple::tuple(0x7ffded6fd110) {
		[168276]	std::_Tuple_impl::_Tuple_impl(0x7ffded6fd110) {
		[168276]	std::_Tuple_impl::_Tuple_impl(0x7ffded6fd110) {
		[168276]	std::_Head_base::_Head_base(0x7ffded6fd110) {
0.266 us		[168276]	std::default_delete::default_delete(0x7ffded6fd110);
1.674 us		[168276]	} /* std::_Head_base::_Head_base */
6.320 us		[168276]	} /* std::_Tuple_impl::_Tuple_impl */
0.227 us		[168276]	std::_Head_base::_Head_base(0x7ffded6fd110);
7.850 us		[168276]	} /* std::_Tuple_impl::_Tuple_impl */
8.500 us		[168276]	} /* std::tuple::tuple */
		[168276]	std::get(0x7ffded6fd110) {
		[168276]	std::_get_helper(0x7ffded6fd110) {
		[168276]	std::_Tuple_impl::_M_head(0x7ffded6fd110) {
0.226 us		[168276]	std::_Head_base::_M_head(0x7ffded6fd110) = 0x7ffded6fd110;
1.290 us		[168276]	} = 0x7ffded6fd110; /* std::_Tuple_impl::_M_head */
2.113 us		[168276]	} = 0x7ffded6fd110; /* std::_get_helper */
2.816 us		[168276]	} = 0x7ffded6fd110; /* std::get */
12.870 us		[168276]	} /* std::unique_ptr::unique_ptr */
		[168276]	std::unique_ptr::~~unique_ptr(0x7ffded6fd110) {
		[168276]	std::get(0x7ffded6fd110) {
		[168276]	std::_get_helper(0x7ffded6fd110) {
		[168276]	std::_Tuple_impl::_M_head(0x7ffded6fd110) {
0.210 us		[168276]	std::_Head_base::_M_head(0x7ffded6fd110) = 0x7ffded6fd110;
1.093 us		[168276]	} = 0x7ffded6fd110; /* std::_Tuple_impl::_M_head */
1.646 us		[168276]	} = 0x7ffded6fd110; /* std::_get_helper */
2.220 us		[168276]	} = 0x7ffded6fd110; /* std::get */
		[168276]	std::unique_ptr::get_deleter(0x7ffded6fd110) {
		[168276]	std::get(0x7ffded6fd110) {
		[168276]	std::_get_helper(0x7ffded6fd110) {
		[168276]	std::_Tuple_impl::_M_head(0x7ffded6fd110) {
0.213 us		[168276]	std::_Head_base::_M_head(0x7ffded6fd110) = 0x7ffded6fd110;
1.094 us		[168276]	} = 0x7ffded6fd110; /* std::_Tuple_impl::_M_head */
1.747 us		[168276]	} = 0x7ffded6fd110; /* std::_get_helper */
2.391 us		[168276]	} = 0x7ffded6fd110; /* std::get */
3.223 us		[168276]	} = 0x7ffded6fd110; /* std::unique_ptr::get_deleter */
		[168276]	std::default_delete::operator()(0x7ffded6fd110, 0xbdbb40) {
		[168276]	operator delete (0xbdbb40) {
1.810 us		[168276]	free (0xbdbb40);
5.230 us		[168276]	} /* operator delete */
6.213 us		[168276]	} /* std::default_delete::operator() */
13.271 us		[168276]	} /* std::unique_ptr::~~unique_ptr */
40.624 us		[168276]	} = 0; /* main */

#	DURATION	TID	FUNCTION
		[168276]	main() {
		[168276]	operator new(4) {
1.094 us		[168276]	malloc(4) = 0xbdbb40;
8.114 us		[168276]	} = 0xbdbb40; /* operator new */
		[168276]	std::unique_ptr::unique_ptr(0x7ffded6fd110, 0xbdbb40) {
		[168276]	std::tuple::tuple(0x7ffded6fd110) {
		[168276]	std::_Tuple_impl::_Tuple_impl(0x7ffded6fd110) {
		[168276]	std::_Tuple_impl::_Tuple_impl(0x7ffded6fd110) {
		[168276]	std::_Head_base::_Head_base(0x7ffded6fd110) {
0.266 us		[168276]	std::default_delete::default_delete(0x7ffded6fd110);
1.674 us		[168276]	} /* std::_Head_base::_Head_base */
6.320 us		[168276]	} /* std::_Tuple_impl::_Tuple_impl */
0.227 us		[168276]	std::_Head_base::_Head_base(0x7ffded6fd110);
7.850 us		[168276]	} /* std::_Tuple_impl::_Tuple_impl */
8.500 us		[168276]	} /* std::tuple::tuple */
		[168276]	std::get(0x7ffded6fd110) {
		[168276]	std::_get_helper(0x7ffded6fd110) {
		[168276]	std::_Tuple_impl::_M_head(0x7ffded6fd110) {
0.226 us		[168276]	std::_Head_base::_M_head(0x7ffded6fd110) = 0x7ffded6fd110;
1.290 us		[168276]	} = 0x7ffded6fd110; /* std::_Tuple_impl::_M_head */
2.113 us		[168276]	} = 0x7ffded6fd110; /* std::_get_helper */
2.816 us		[168276]	} = 0x7ffded6fd110; /* std::get */
12.870 us		[168276]	} /* std::unique_ptr::unique_ptr */
		[168276]	std::unique_ptr::~unique_ptr(0x7ffded6fd110) {
		[168276]	std::get(0x7ffded6fd110) {
		[168276]	std::_get_helper(0x7ffded6fd110) {
		[168276]	std::_Tuple_impl::_M_head(0x7ffded6fd110) {
0.210 us		[168276]	std::_Head_base::_M_head(0x7ffded6fd110) = 0x7ffded6fd110;
1.093 us		[168276]	} = 0x7ffded6fd110; /* std::_Tuple_impl::_M_head */
1.646 us		[168276]	} = 0x7ffded6fd110; /* std::_get_helper */
2.220 us		[168276]	} = 0x7ffded6fd110; /* std::get */
		[168276]	std::unique_ptr::get_deleter(0x7ffded6fd110) {
		[168276]	std::get(0x7ffded6fd110) {
		[168276]	std::_get_helper(0x7ffded6fd110) {
		[168276]	std::_Tuple_impl::_M_head(0x7ffded6fd110) {
0.213 us		[168276]	std::_Head_base::_M_head(0x7ffded6fd110) = 0x7ffded6fd110;
1.094 us		[168276]	} = 0x7ffded6fd110; /* std::_Tuple_impl::_M_head */
1.747 us		[168276]	} = 0x7ffded6fd110; /* std::_get_helper */
2.391 us		[168276]	} = 0x7ffded6fd110; /* std::get */
3.223 us		[168276]	} = 0x7ffded6fd110; /* std::unique_ptr::get_deleter */
		[168276]	std::default_delete::operator()(0x7ffded6fd110, 0xbdbb40) {
		[168276]	operator delete(0xbdbb40) {
1.810 us		[168276]	free(0xbdbb40);
5.230 us		[168276]	} /* operator delete */
6.213 us		[168276]	} /* std::default_delete::operator() */
13.271 us		[168276]	} /* std::unique_ptr::~unique_ptr */
40.624 us		[168276]	} = 0; /* main */

최적화를 안한 경우의
전체 내부 함수 호출

std::make_shared

std::shared_ptr 보다 std::make_shared 를
사용하길 권장하는 이유


```
$ cat shared_ptr.cc
```

```
#include <memory>
```

```
int main()
```

```
{
```

```
    std::shared_ptr<int> p(new int);
```

```
}
```

```
$ cat shared_ptr.cc  
#include <memory>
```

```
int main()  
{  
    std::shared_ptr<int> p(new int);  
}
```

```
$ g++ -std=c++11 -pg -O2 -o shared_ptr shared_ptr.cc
```

```
$ cat shared_ptr.cc
#include <memory>
```

```
int main()
{
    std::shared_ptr<int> p(new int);
}
```

```
$ g++ -std=c++11 -pg -O2 -o shared_ptr shared_ptr.cc
```

```
$ uftrace -a shared_ptr
```

#	DURATION	TID	FUNCTION
		[6257]	main() {
9.740	us	[6257]	operator new(4) = 0x1b57160;
0.470	us	[6257]	operator new(24) = 0x1bb6ad0;
		[6257]	std::_Sp_counted_ptr::_M_dispose() {
2.946	us	[6257]	operator delete(0x1b57160);
4.294	us	[6257]	} /* std::_Sp_counted_ptr::_M_dispose */
		[6257]	std::_Sp_counted_ptr::_M_destroy() {
0.373	us	[6257]	operator delete(0x1bb6ad0);
1.067	us	[6257]	} /* std::_Sp_counted_ptr::_M_destroy */
23.420	us	[6257]	} /* main */

```
$ cat shared_ptr.cc
#include <memory>
```

```
int main()
{
    std::shared_ptr<int> p(new int);
}
```

```
$ g++ -std=c++11 -pg -O2 -o shared_ptr shared_ptr.cc
```

```
$ uftrace -a shared_ptr
```

#	DURATION	TID	FUNCTION
		[6257]	main() {
9.740	us	[6257]	operator new(4) = 0x1b57160;
0.470	us	[6257]	operator new(24) = 0x1bb6ad0;
		[6257]	std::_Sp_counted_ptr::_M_dispose() {
2.946	us	[6257]	operator delete(0x1b57160);
4.294	us	[6257]	} /* std::_Sp_counted_ptr::_M_dispose */
		[6257]	std::_Sp_counted_ptr::_M_destroy() {
0.373	us	[6257]	operator delete(0x1bb6ad0);
1.067	us	[6257]	} /* std::_Sp_counted_ptr::_M_destroy */
23.420	us	[6257]	} /* main */

**사용할 포인터와
관리객체를 별도로 할당**

```
$ uftrace -a --nest-libcall -t 100s -T malloc@trace -T free@trace a.out
```

```
# DURATION      TID      FUNCTION
[ 6173] | main() {
[ 6173] |   operator new(4) {
1.025 us [ 6173] |     malloc(4) = 0x1019d80;
6.012 us [ 6173] |   } = 0x1019d80; /* operator new */
[ 6173] |   std::shared_ptr::shared_ptr() {
[ 6173] |     std::__shared_ptr::__shared_ptr() {
[ 6173] |       std::__shared_count::__shared_count() {
[ 6173] |         operator new(24) {
0.365 us [ 6173] |           malloc(24) = 0x1019da0;
4.120 us [ 6173] |         } = 0x1019da0; /* operator new */
6.022 us [ 6173] |       } /* std::__shared_count::__shared_count */
7.105 us [ 6173] |     } /* std::__shared_ptr::__shared_ptr */
7.530 us [ 6173] |   } /* std::shared_ptr::shared_ptr */
[ 6173] |   std::shared_ptr::~~shared_ptr() {
[ 6173] |     std::__shared_ptr::~~__shared_ptr() {
[ 6173] |       std::__shared_count::~~__shared_count() {
[ 6173] |         std::_Sp_counted_base::_M_release() {
[ 6173] |           std::_Sp_counted_ptr::_M_dispose() {
[ 6173] |             operator delete(0x1019d80) {
1.360 us [ 6173] |               free(0x1019d80);
3.645 us [ 6173] |             } /* operator delete */
4.197 us [ 6173] |           } /* std::_Sp_counted_ptr::_M_dispose */
[ 6173] |         std::_Sp_counted_ptr::_M_destroy() {
[ 6173] |           std::_Sp_counted_ptr::~~_Sp_counted_ptr() {
[ 6173] |             operator delete(0x1019da0) {
2.603 us [ 6173] |               free(0x1019da0);
3.317 us [ 6173] |             } /* operator delete */
4.450 us [ 6173] |           } /* std::_Sp_counted_ptr::~~_Sp_counted_ptr */
4.835 us [ 6173] |         } /* std::_Sp_counted_ptr::_M_destroy */
11.683 us [ 6173] |       } /* std::_Sp_counted_base::_M_release */
12.035 us [ 6173] |     } /* std::__shared_count::~~__shared_count */
12.407 us [ 6173] |   } /* std::__shared_ptr::~~__shared_ptr */
12.740 us [ 6173] | } /* std::shared_ptr::~~shared_ptr */
30.397 us [ 6173] | } /* main */
```

```
$ ufttrace -a --nest-libcall -t 100s -T malloc@trace -T free@trace a.out
```

```
# DURATION      TID      FUNCTION
[ 6173] | main() {
[ 6173] |     operator new(4) {
1.025 us [ 6173] |         malloc(4) = 0x1019d80;
6.012 us [ 6173] |     } = 0x1019d80; /* operator new */
[ 6173] |     std::shared_ptr::shared_ptr() {
[ 6173] |         std::__shared_ptr::__shared_ptr() {
[ 6173] |             std::__shared_count::__shared_count() {
[ 6173] |                 operator new(24) {
0.365 us [ 6173] |                     malloc(24) = 0x1019da0;
4.120 us [ 6173] |                     } = 0x1019da0; /* operator new */
6.022 us [ 6173] |                 } /* std::__shared_count::__shared_count */
7.105 us [ 6173] |             } /* std::__shared_ptr::__shared_ptr */
7.530 us [ 6173] |         } /* std::shared_ptr::shared_ptr */
[ 6173] |     std::shared_ptr::~~shared_ptr() {
[ 6173] |         std::__shared_ptr::~~__shared_ptr() {
[ 6173] |             std::__shared_count::~~__shared_count() {
[ 6173] |                 std::_Sp_counted_base::_M_release() {
[ 6173] |                     std::_Sp_counted_ptr::_M_dispose() {
[ 6173] |                         operator delete(0x1019d80) {
1.360 us [ 6173] |                             free(0x1019d80);
3.645 us [ 6173] |                         } /* operator delete */
4.197 us [ 6173] |                     } /* std::_Sp_counted_ptr::_M_dispose */
[ 6173] |                 std::_Sp_counted_ptr::_M_destroy() {
[ 6173] |                     std::_Sp_counted_ptr::~~_Sp_counted_ptr() {
[ 6173] |                         operator delete(0x1019da0) {
2.603 us [ 6173] |                             free(0x1019da0);
3.317 us [ 6173] |                         } /* operator delete */
4.450 us [ 6173] |                     } /* std::_Sp_counted_ptr::~~_Sp_counted_ptr */
4.835 us [ 6173] |                 } /* std::_Sp_counted_ptr::_M_destroy */
11.683 us [ 6173] |             } /* std::_Sp_counted_base::_M_release */
12.035 us [ 6173] |         } /* std::__shared_count::~~__shared_count */
12.407 us [ 6173] |     } /* std::__shared_ptr::~~__shared_ptr */
12.740 us [ 6173] | } /* std::shared_ptr::~~shared_ptr */
30.397 us [ 6173] | } /* main */
```

최적화를 안한
이미지의
함수 호출 결과

\$ ufttrace -a --nest-libcall -t 100s -T malloc@trace -T free@trace a.out

#	DURATION	TID	FUNCTION
		[6173]	main() {
		[6173]	operator new(4) {
1.025 us		[6173]	malloc(4) = 0x1019d80;
6.012 us		[6173]	} = 0x1019d80; /* operator new */
		[6173]	std::shared_ptr::shared_ptr() {
		[6173]	std::__shared_ptr::__shared_ptr() {
		[6173]	std::__shared_count::__shared_count() {
		[6173]	operator new(24) {
0.365 us		[6173]	malloc(24) = 0x1019da0;
4.120 us		[6173]	} = 0x1019da0; /* operator new */
6.022 us		[6173]	} /* std::__shared_count::__shared_count */
7.105 us		[6173]	} /* std::__shared_ptr::__shared_ptr */
7.530 us		[6173]	} /* std::shared_ptr::shared_ptr */
		[6173]	std::shared_ptr::~~shared_ptr() {
		[6173]	std::__shared_ptr::~~__shared_ptr() {
		[6173]	std::__shared_count::~~__shared_count() {
		[6173]	std::_Sp_counted_base::_M_release() {
		[6173]	std::_Sp_counted_ptr::_M_dispose() {
		[6173]	operator delete(0x1019d80) {
1.360 us		[6173]	free(0x1019d80);
3.645 us		[6173]	} /* operator delete */
4.197 us		[6173]	} /* std::_Sp_counted_ptr::_M_dispose */
		[6173]	std::_Sp_counted_ptr::_M_destroy() {
		[6173]	std::_Sp_counted_ptr::~~_Sp_counted_ptr() {
		[6173]	operator delete(0x1019da0) {
2.603 us		[6173]	free(0x1019da0);
3.317 us		[6173]	} /* operator delete */
4.450 us		[6173]	} /* std::_Sp_counted_ptr::~~_Sp_counted_ptr */
4.835 us		[6173]	} /* std::_Sp_counted_ptr::_M_destroy */
11.683 us		[6173]	} /* std::_Sp_counted_base::_M_release */
12.035 us		[6173]	} /* std::__shared_count::~~__shared_count */
12.407 us		[6173]	} /* std::__shared_ptr::~~__shared_ptr */
12.740 us		[6173]	} /* std::shared_ptr::~~shared_ptr */
30.397 us		[6173]	} /* main */

trace trigger 를
사용해 malloc, free 로
도달하는 경로만
기록하고 나머지는 무시
(-t 시간을 크게 설정)

최적화를 안한
이미지의
함수 호출 결과

```
$ cat make_shared.cc
```

```
#include <memory>
```

```
int main()
```

```
{
```

```
    auto p = std::make_shared<int>();
```

```
}
```



```
$ cat make_shared.cc  
#include <memory>
```

```
  
int main()  
{  
    auto p = std::make_shared<int>();  
}
```

```
$ g++ -std=c++11 -pg -O2 -o make_shared make_shared.cc
```

```
$ cat make_shared.cc
#include <memory>
```

```
int main()
{
    auto p = std::make_shared<int>();
}
```

```
$ g++ -std=c++11 -pg -O2 -o make_shared make_shared.cc
```

```
$ uftrace -a make_shared
```

#	DURATION	TID	FUNCTION
		[6328]	main() {
2.341	us	[6328]	operator new(24) = 0x1b48fa0;
		[6328]	std::_Sp_counted_ptr_inplace::_M_destroy() {
2.058	us	[6328]	operator delete(0x1b48fa0);
2.636	us	[6328]	} /* std::_Sp_counted_ptr_inplace::_M_destroy */
8.826	us	[6328]	} /* main */

```
$ cat make_shared.cc
#include <memory>
```

```
int main()
{
    auto p = std::make_shared<int>();
}
```

```
$ g++ -std=c++11 -pg -O2 -o make_shared make_shared.cc
```

```
$ uftrace -a make_shared
```

#	DURATION	TID	FUNCTION
		[6328]	main() {
2.341	us	[6328]	operator new(24) = 0x1b48fa0;
		[6328]	std::_Sp_counted_ptr_inplace::_M_destroy() {
2.058	us	[6328]	operator delete(0x1b48fa0);
2.636	us	[6328]	} /* std::_Sp_counted_ptr_inplace::_M_destroy */
8.826	us	[6328]	} /* main */

**shared_ptr 은 _Sp_counted_ptr 사용하지만
make_shared 는 _Sp_counted_ptr_inplace 사용해
메모리 할당을 단 한번만!**

constexpr Function

컴파일 타임 함수 실행
(or maybe not)

```
#include <stdio>
#include <stdlib>

constexpr int fib(const int n)
{
    if (n <= 2)
        return 1;
    return fib(n - 1) + fib(n - 2);
}

int main(int argc, char* argv[])
{
    constexpr int n = 7;
    const int result = fib(n);
    printf("%d\n", result);

    return fib(5);
}
```

```
$ g++ -pg -std=c++14 constexpr.cpp
$ uftrace -A fib@arg1/u -R fib@retval -A printf@arg1/s,arg2/i a.out
13
```

#	DURATION	TID	FUNCTION
	1.540 us	[160012]	__monstartup();
	0.900 us	[160012]	__cxa_atexit();
		[160012]	main() {
	8.884 us	[160012]	printf("%d\n", 13);
		[160012]	fib(5) {
		[160012]	fib(4) {
		[160012]	fib(3) {
	3.130 us	[160012]	fib(2) = 1;
	0.193 us	[160012]	fib(1) = 1;
	4.860 us	[160012]	} = 2; /* fib */
	0.210 us	[160012]	fib(2) = 1;
	5.873 us	[160012]	} = 3; /* fib */
		[160012]	fib(3) {
	0.140 us	[160012]	fib(2) = 1;
	0.180 us	[160012]	fib(1) = 1;
	1.137 us	[160012]	} = 2; /* fib */
	7.880 us	[160012]	} = 5; /* fib */
	18.283 us	[160012]	} /* main */

```
$ g++ -pg -std=c++14 constexpr.cpp
$ uftrace -A fib@arg1/u -R fib@retval -A printf@arg1/s,arg2/i a.out
13
```

#	DURATION	TID	FUNCTION
	1.540 us	[160012]	__monstartup();
	0.900 us	[160012]	__cxa_atexit();
		[160012]	main() {
	8.884 us	[160012]	printf("%d\n", 13);
		[160012]	fib(5) {
		[160012]	fib(4) {
		[160012]	fib(3) {
	3.130 us	[160012]	fib(2) = 1;
	0.193 us	[160012]	fib(1) = 1;
	4.860 us	[160012]	} = 2; /* fib */
	0.210 us	[160012]	fib(2) = 1;
	5.873 us	[160012]	} = 3; /* fib */
		[160012]	fib(3) {
	0.140 us	[160012]	fib(2) = 1;
	0.180 us	[160012]	fib(1) = 1;
	1.137 us	[160012]	} = 2; /* fib */
	7.880 us	[160012]	} = 5; /* fib */
	18.283 us	[160012]	} /* main */

```
$ g++ -pg -std=c++14 constexpr.cpp
$ uftrace -A fib@arg1/u -R fib@retval -A printf@arg1/s,arg2/i a.out
13
```

#	DURATION	TID	FUNCTION
	1.540 us	[160012]	__monstartup();
	0.900 us	[160012]	__cxa_atexit();
		[160012]	main() {
	8.884 us	[160012]	printf("%d\n", 13);
		[160012]	fib(5) {
		[160012]	fib(4) {
		[160012]	fib(3) {
	3.130 us	[160012]	fib(2) = 1;
	0.193 us	[160012]	fib(1) = 1;
	4.860 us	[160012]	} = 2; /* fib */
	0.210 us	[160012]	fib(2) = 1;
	5.873 us	[160012]	} = 3; /* fib */
		[160012]	fib(3) {
	0.140 us	[160012]	fib(2) = 1;
	0.180 us	[160012]	fib(1) = 1;
	1.137 us	[160012]	} = 2; /* fib */
	7.880 us	[160012]	} = 5; /* fib */
	18.283 us	[160012]	} /* main */

But...

```
#include <stdio>
#include <stdlib>

constexpr int fib(const int n)
{
    if (n <= 2)
        return 1;
    return fib(n - 1) + fib(n - 2);
}

int main()
{
    constexpr int n = 7;
    const int result = fib(n);
    printf("fib(%d) = %d\n", n, result);

    return fib(5);
}
```

```
#include <stdio>
#include <stdlib>

constexpr int fib(const int n)
{
    if (n <= 2)
        return 1;
    return fib(n - 1) + fib(n - 2);
}

int main()
{
    constexpr int n = 7;
    const int result = fib(n);
    printf("fib(%d) = %d\n", n, result);

    return fib(5);
}
```

```
$ clang++ -pg -std=c++14 constexpr.cpp
$ uftrace -A fib@arg1/u -R fib@retval -A printf@arg1/s,arg2/i a.out
13
```

```
# DURATION      TID      FUNCTION
    [20035] | main() {
    [20035] |   fib(7) {
    [20035] |     fib(6) {
    [20035] |       fib(5) {
    [20035] |         fib(4) {
    [20035] |           fib(3) {
0.380 us [20035] |             fib(2) = 1;
0.194 us [20035] |             fib(1) = 1;
3.117 us [20035] |             } = 2; /* fib */
0.167 us [20035] |             fib(2) = 1;
6.687 us [20035] |             } = 3; /* fib */
    [20035] |           fib(3) {
0.150 us [20035] |             fib(2) = 1;
0.156 us [20035] |             fib(1) = 1;
1.130 us [20035] |             } = 2; /* fib */
8.407 us [20035] |             } = 5; /* fib */
    ...
```

**컴파일러 내부 구현의 차이에 의해
clang에서는 다른 결과를 보임**

std::string_view

C++17

```
$ cat string.cpp
#include <iostream>
```

```
int main()
{
    const char* msg = "std::string test!";
    print_string(msg);
}
```

```
$ cat string.cpp
```

```
#include <iostream>
```

```
#include <string>
```

```
void print_string(const std::string& s)
```

```
{
```

```
    std::cout << s << '\n';
```

```
}
```

```
int main()
```

```
{
```

```
    const char* msg = "std::string test!";
```

```
    print_string(msg);
```

```
}
```

```
$ g++ -pg string.cpp -o string
$ uftrace -F main -D 3 string
std::string test!
```



```
$ g++ -pg string.cpp -o string
```

```
$ uftrace -F main -D 3 string
```

```
std::string test!
```

#	DURATION	TID	FUNCTION
		[126472]	main() {
1.430	us	[126472]	std::allocator::allocator();
		[126472]	std::__cxx11::basic_string::basic_string() {
0.720	us	[126472]	std::__cxx11::basic_string::_M_local_data();
1.306	us	[126472]	std::__cxx11::basic_string::_Alloc_hider::_Alloc_hider();
0.214	us	[126472]	std::char_traits::length();
6.544	us	[126472]	std::__cxx11::basic_string::_M_construct();
10.346	us	[126472]	} /* std::__cxx11::basic_string::basic_string */
		[126472]	print_string() {
19.283	us	[126472]	std::operator <<();
2.464	us	[126472]	std::operator <<();
22.713	us	[126472]	} /* print_string */
		[126472]	std::__cxx11::basic_string::~~basic_string() {
3.820	us	[126472]	std::__cxx11::basic_string::_M_dispose();
1.303	us	[126472]	std::__cxx11::basic_string::_Alloc_hider::~~_Alloc_hider();
5.843	us	[126472]	} /* std::__cxx11::basic_string::~~basic_string */
0.850	us	[126472]	std::allocator::~~allocator();
44.803	us	[126472]	} /* main */

```
$ g++ -pg string.cpp -o string
```

```
$ uftrace -F main -D 3 string
```

```
std::string test!
```

#	DURATION	TID	FUNCTION
		[126472]	main() {
1.430	us	[126472]	std::allocator::allocator();
		[126472]	std::__cxx11::basic_string::basic_string() {
0.720	us	[126472]	std::__cxx11::basic_string::_M_local_data();
1.306	us	[126472]	std::__cxx11::basic_string::_Alloc_hider::_Alloc_hider();
0.214	us	[126472]	std::char_traits::length();
6.544	us	[126472]	std::__cxx11::basic_string::_M_construct();
10.346	us	[126472]	} /* std::__cxx11::basic_string::basic_string */
		[126472]	print_string() {
19.283	us	[126472]	std::operator <<();
2.464	us	[126472]	std::operator <<();
22.713	us	[126472]	} /* print_string */
		[126472]	std::__cxx11::basic_string::~~basic_string() {
3.820	us	[126472]	std::__cxx11::basic_string::_M_dispose();
1.303	us	[126472]	std::__cxx11::basic_string::_Alloc_hider::~~_Alloc_hider();
5.843	us	[126472]	} /* std::__cxx11::basic_string::~~basic_string */
0.850	us	[126472]	std::allocator::~~allocator();
44.803	us	[126472]	} /* main */

```
$ g++ -pg string.cpp -o string
```

```
$ uftrace -F main -D 3 string
```

```
std::string test!
```

```
# DURATION      TID      FUNCTION
      [126472] | main() {
1.430 us [126472] |   std::allocator::allocator();
      [126472] |   std::__cxx11::basic_string::basic_string() {
0.720 us [126472] |       std::__cxx11::basic_string::_M_local_data();
1.306 us [126472] |       std::__cxx11::basic_string::_Alloc_hider::_Alloc_hider();
0.214 us [126472] |       std::char_traits::length();
6.544 us [126472] |       std::__cxx11::basic_string::_M_construct();
10.346 us [126472] |   } /* std::__cxx11::basic_string::basic_string */
      [126472] |   print_string() {
19.283 us [126472] |       std::operator <<();
  2.464 us [126472] |       std::operator <<();
22.713 us [126472] |   } /* print_string */
      [126472] |   std::__cxx11::basic_string::~~basic_string() {
  3.820 us [126472] |       std::__cxx11::basic_string::_M_dispose();
  1.303 us [126472] |       std::__cxx11::basic_string::_Alloc_hider::~~_Alloc_hider();
  5.843 us [126472] |   } /* std::__cxx11::basic_string::~~basic_string */
  0.850 us [126472] |   std::allocator::~~allocator();
44.803 us [126472] | } /* main */
```

```
$ g++ -pg -O2 string.cpp -o string2
```

```
$ uftrace -F main -D 3 string2
```

```
std::string test!
```

```
$ g++ -pg string.cpp -o string
```

```
$ uftrace -F main -D 3 string
```

```
std::string test!
```

#	DURATION	TID	FUNCTION
		[126472]	main() {
1.430	us	[126472]	std::allocator::allocator();
		[126472]	std::__cxx11::basic_string::basic_string() {
0.720	us	[126472]	std::__cxx11::basic_string::_M_local_data();
1.306	us	[126472]	std::__cxx11::basic_string::_Alloc_hider::_Alloc_hider();
0.214	us	[126472]	std::char_traits::length();
6.544	us	[126472]	std::__cxx11::basic_string::_M_construct();
10.346	us	[126472]	} /* std::__cxx11::basic_string::basic_string */
		[126472]	print_string() {
19.283	us	[126472]	std::operator <<();
2.464	us	[126472]	std::operator <<();
22.713	us	[126472]	} /* print_string */
		[126472]	std::__cxx11::basic_string::~~basic_string() {
3.820	us	[126472]	std::__cxx11::basic_string::_M_dispose();
1.303	us	[126472]	std::__cxx11::basic_string::_Alloc_hider::~~_Alloc_hider();
5.843	us	[126472]	} /* std::__cxx11::basic_string::~~basic_string */
0.850	us	[126472]	std::allocator::~~allocator();
44.803	us	[126472]	} /* main */

```
$ g++ -pg -O2 string.cpp -o string2
```

```
$ uftrace -F main -D 3 string2
```

```
std::string test!
```

#	DURATION	TID	FUNCTION
		[126639]	main() {
1.807	us	[126639]	operator new();
		[126639]	print_string() {
11.350	us	[126639]	std::__ostream_insert();
0.514	us	[126639]	std::__ostream_insert();
13.033	us	[126639]	} /* print_string */
2.440	us	[126639]	operator delete();
20.010	us	[126639]	} /* main */

```
$ cat string.cpp
```

```
#include <iostream>
```

```
#include <string>
```

```
void print_string(const std::string& s)
```

```
{
```

```
    std::cout << s << '\n';
```

```
}
```

```
int main()
```

```
{
```

```
    const char* msg = "std::string test!";
```

```
    print_string(msg);
```

```
}
```

```
$ cat string_view.cpp
```

```
#include <iostream>
```

```
#include <string_view>
```

```
void print_string_view(const std::string_view& sv)
```

```
{
```

```
    std::cout << sv << '\n';
```

```
}
```

```
int main()
```

```
{
```

```
    const char* msg = "std::string_view!";
```

```
    print_string_view(msg);
```

```
}
```

```
$ g++ -std=c++17 -pg string_view.cpp -o string_view
$ uftrace -F main -D 3 string_view
std::string_view!
```

```
$ g++ -std=c++17 -pg string_view.cpp -o string_view
```

```
$ uftrace -F main -D 3 string_view
```

```
std::string_view!
```

#	DURATION	TID	FUNCTION
		[126684]	main() {
		[126684]	std::basic_string_view::basic_string_view() {
0.380	us	[126684]	std::char_traits::length();
1.786	us	[126684]	} /* std::basic_string_view::basic_string_view */
		[126684]	print_string_view() {
7.970	us	[126684]	std::operator <<();
2.590	us	[126684]	std::operator <<();
11.767	us	[126684]	} /* print_string_view */
14.966	us	[126684]	} /* main */


```
$ g++ -std=c++17 -pg string_view.cpp -o string_view
```

```
$ uftrace -F main -D 3 string_view
```

```
std::string_view!
```

#	DURATION	TID	FUNCTION
		[126684]	main() {
		[126684]	std::basic_string_view::basic_string_view() {
0.380	us	[126684]	std::char_traits::length();
1.786	us	[126684]	} /* std::basic_string_view::basic_string_view */
		[126684]	print_string_view() {
7.970	us	[126684]	std::operator <<();
2.590	us	[126684]	std::operator <<();
11.767	us	[126684]	} /* print_string_view */
14.966	us	[126684]	} /* main */

```
$ g++ -std=c++1z -pg -O2 string_view.cpp -o string_view2
```

```
$ uftrace -F main -D 3 string_view2
```

```
std::string_view!
```

```
$ g++ -std=c++17 -pg string_view.cpp -o string_view
```

```
$ uftrace -F main -D 3 string_view
```

```
std::string_view!
```

#	DURATION	TID	FUNCTION
		[126684]	main() {
		[126684]	std::basic_string_view::basic_string_view() {
0.380	us	[126684]	std::char_traits::length();
1.786	us	[126684]	} /* std::basic_string_view::basic_string_view */
		[126684]	print_string_view() {
7.970	us	[126684]	std::operator <<();
2.590	us	[126684]	std::operator <<();
11.767	us	[126684]	} /* print_string_view */
14.966	us	[126684]	} /* main */

```
$ g++ -std=c++1z -pg -O2 string_view.cpp -o string_view2
```

```
$ uftrace -F main -D 3 string_view2
```

```
std::string_view!
```

#	DURATION	TID	FUNCTION
		[126698]	main() {
		[126698]	print_string_view() {
12.024	us	[126698]	std::__ostream_insert();
0.546	us	[126698]	std::__ostream_insert();
14.674	us	[126698]	} /* print_string_view */
15.613	us	[126698]	} /* main */

**std::string 객체를 만들기 위한
불필요한 메모리 할당과 해제가 없음!**

Clang / LLVM

Analyzing Clang

```
$ uftrace -t 2ms -F ccl_main ./clang fibonacci.c
```

#	DURATION	TID	FUNCTION
		[9045]	ccl_main() {
		[9045]	clang::CompilerInvocation::CreateFromArgs() {
2.270 ms		[9045]	ParseCodeGenArgs();
8.653 ms		[9045]	} /* clang::CompilerInvocation::CreateFromArgs */
		[9045]	clang::ExecuteCompilerInvocation() {
		[9045]	clang::CompilerInstance::ExecuteAction() {
2.185 ms		[9045]	clang::FrontendAction::BeginSourceFile();
		[9045]	clang::FrontendAction::Execute() {
		[9045]	clang::CodeGenAction::ExecuteAction() {
		[9045]	clang::ASTFrontendAction::ExecuteAction() {
		[9045]	clang::ParseAST() {
		[9045]	clang::Parser::Initialize() {
3.841 ms		[9045]	clang::Preprocessor::Lex();
3.887 ms		[9045]	} /* clang::Parser::Initialize */
		[9045]	clang::BackendConsumer::HandleTranslationUnit() {
		[9045]	clang::EmitBackendOutput() {
		[9045]	llvm::LLVMTargetMachine::addPassesToEmitFile() {
2.044 ms		[9045]	addPassesToGenerateCode();
2.068 ms		[9045]	} /* llvm::LLVMTargetMachine::addPassesToEmitFile */
		[9045]	llvm::legacy::PassManager::run() {
2.196 ms		[9045]	llvm::legacy::PassManagerImpl::run();
2.196 ms		[9045]	} /* llvm::legacy::PassManager::run */
5.053 ms		[9045]	} /* clang::EmitBackendOutput */
5.076 ms		[9045]	} /* clang::BackendConsumer::HandleTranslationUnit */
23.361 ms		[9045]	} /* clang::ParseAST */
23.385 ms		[9045]	} /* clang::ASTFrontendAction::ExecuteAction */
23.385 ms		[9045]	} /* clang::CodeGenAction::ExecuteAction */
23.386 ms		[9045]	} /* clang::FrontendAction::Execute */
25.651 ms		[9045]	} /* clang::CompilerInstance::ExecuteAction */
25.667 ms		[9045]	} /* clang::ExecuteCompilerInvocation */
34.368 ms		[9045]	} /* ccl_main */

Analyzing Clang

```
$ uftrace -t 2ms -F ccl_main ./clang fibonacci.c
```

#	DURATION	TID	FUNCTION
		[9045]	ccl_main() {
		[9045]	clang::CompilerInvocation::CreateFromArgs() {
2.270 ms		[9045]	ParseCodeGenArgs();
8.653 ms		[9045]	} /* clang::CompilerInvocation::CreateFromArgs */
		[9045]	clang::ExecuteCompilerInvocation() {
		[9045]	clang::CompilerInstance::ExecuteAction() {
2.185 ms		[9045]	clang::FrontendAction::BeginSourceFile();
		[9045]	clang::FrontendAction::Execute() {
		[9045]	clang::CodeGenAction::ExecuteAction() {
		[9045]	clang::ASTFrontendAction::ExecuteAction() {
		[9045]	clang::ParseAST() {
		[9045]	clang::Parser::Initialize() {
3.841 ms		[9045]	clang::Preprocessor::Lex();
3.887 ms		[9045]	} /* clang::Parser::Initialize */
		[9045]	clang::BackendConsumer::HandleTranslationUnit() {
		[9045]	clang::EmitBackendOutput() {
		[9045]	llvm::LLVMTargetMachine::addPassesToEmitFile() {
2.044 ms		[9045]	addPassesToGenerateCode();
2.068 ms		[9045]	} /* llvm::LLVMTargetMachine::addPassesToEmitFile */
		[9045]	llvm::legacy::PassManager::run() {
2.196 ms		[9045]	llvm::legacy::PassManagerImpl::run();
2.196 ms		[9045]	} /* llvm::legacy::PassManager::run */
5.053 ms		[9045]	} /* clang::EmitBackendOutput */
5.076 ms		[9045]	} /* clang::BackendConsumer::HandleTranslationUnit */
23.361 ms		[9045]	} /* clang::ParseAST */
23.385 ms		[9045]	} /* clang::ASTFrontendAction::ExecuteAction */
23.385 ms		[9045]	} /* clang::CodeGenAction::ExecuteAction */
23.386 ms		[9045]	} /* clang::FrontendAction::Execute */
25.651 ms		[9045]	} /* clang::CompilerInstance::ExecuteAction */
25.667 ms		[9045]	} /* clang::ExecuteCompilerInvocation */
34.368 ms		[9045]	} /* ccl_main */

Analyzing Clang

```
$ uftrace -t 2ms -F ccl_main ./clang fibonacci.c
```

#	DURATION	TID	FUNCTION
		[9045]	ccl_main() {
		[9045]	clang::CompilerInvocation::CreateFromArgs() {
2.270 ms		[9045]	ParseCodeGenArgs();
8.653 ms		[9045]	} /* clang::CompilerInvocation::CreateFromArgs */
		[9045]	clang::ExecuteCompilerInvocation() {
		[9045]	clang::CompilerInstance::ExecuteAction() {
2.185 ms		[9045]	clang::FrontendAction::BeginSourceFile();
		[9045]	clang::FrontendAction::Execute() {
		[9045]	clang::CodeGenAction::ExecuteAction() {
		[9045]	clang::ASTFrontendAction::ExecuteAction() {
		[9045]	clang::ParseAST() {
		[9045]	clang::Parser::Initialize() {
3.841 ms		[9045]	clang::Preprocessor::Lex();
3.887 ms		[9045]	} /* clang::Parser::Initialize */
		[9045]	clang::BackendConsumer::HandleTranslationUnit() {
		[9045]	clang::EmitBackendOutput() {
		[9045]	llvm::LLVMTargetMachine::addPassesToEmitFile() {
2.044 ms		[9045]	addPassesToGenerateCode();
2.068 ms		[9045]	} /* llvm::LLVMTargetMachine::addPassesToEmitFile */
		[9045]	llvm::legacy::PassManager::run() {
2.196 ms		[9045]	llvm::legacy::PassManagerImpl::run();
2.196 ms		[9045]	} /* llvm::legacy::PassManager::run */
5.053 ms		[9045]	} /* clang::EmitBackendOutput */
5.076 ms		[9045]	} /* clang::BackendConsumer::HandleTranslationUnit */
23.361 ms		[9045]	} /* clang::ParseAST */
23.385 ms		[9045]	} /* clang::ASTFrontendAction::ExecuteAction */
23.385 ms		[9045]	} /* clang::CodeGenAction::ExecuteAction */
23.386 ms		[9045]	} /* clang::FrontendAction::Execute */
25.651 ms		[9045]	} /* clang::CompilerInstance::ExecuteAction */
25.667 ms		[9045]	} /* clang::ExecuteCompilerInvocation */
34.368 ms		[9045]	} /* ccl_main */

Analyzing Clang TMP expansion

```
$ clang++ tmpfib.cc
```

```
#include <iostream>

#define fibnum 8
template <unsigned N> struct Fibonacci {
    enum { value = Fibonacci<N-1>::value + Fibonacci<N-2>::value };
};
template <> struct Fibonacci<1> { enum { value = 1 }; };
template <> struct Fibonacci<0> { enum { value = 0 }; };

int main(void)
{
    std::cout << "Fibonacci(" << fibnum << ") = ";
    std::cout << Fibonacci<fibnum>::value;
    std::cout << std::endl;
}
```

Analyzing Clang TMP expansion

```
$ clang++ tmpfib.cc
```

```
#include <iostream>

#define fibnum 8
template <unsigned N> struct Fibonacci {
    enum { value = Fibonacci<N-1>::value + Fibonacci<N-2>::value };
};
template <> struct Fibonacci<1> { enum { value = 1 }; };
template <> struct Fibonacci<0> { enum { value = 0 }; };

int main(void)
{
    std::cout << "Fibonacci(" << fibnum << ") = ";
    std::cout << Fibonacci<fibnum>::value;
    std::cout << std::endl;
}
```


Analyzing Clang TMP expansion

```
$ clang++ tmpfib.cc
```

```
#include <iostream>
```

```
#define fibnum 8
```

Recursive Expansion

```
template <unsigned N> struct Fibonacci {  
    enum { value = Fibonacci<N-1>::value + Fibonacci<N-2>::value };  
};  
template <> struct Fibonacci<1> { enum { value = 1 }; };  
template <> struct Fibonacci<0> { enum { value = 0 }; };
```

```
int main(void)
```

```
{  
    std::cout << "Fibonacci(" << fibnum << ") = ";  
    std::cout << Fibonacci<fibnum>::value;  
    std::cout << std::endl;  
}
```

Analyzing Clang TMP expansion

```
$ clang++ tmpfib.cc
```

```
#include <iostream>
```

```
#define fibnum 8
```

Recursive Expansion

```
template <unsigned N> struct Fibonacci {  
    enum { value = Fibonacci<N-1>::value + Fibonacci<N-2>::value };  
};  
template <> struct Fibonacci<1> { enum { value = 1 }; };  
template <> struct Fibonacci<0> { enum { value = 0 }; };
```

```
int main(void)
```

```
{  
    std::cout << "Fibonacci(" << fibnum << ") = ";  
    std::cout << Fibonacci<fibnum>::value;  
    std::cout << std::endl;  
}
```

Analyzing Clang TMP expansion

```
$ uftrace record -t 1ms clang++ tmpfib.cc
```

```
#include <iostream>
```

```
#define fibnum 8
```

Recursive Expansion

```
template <unsigned N> struct Fibonacci {  
    enum { value = Fibonacci<N-1>::value + Fibonacci<N-2>::value };  
};  
template <> struct Fibonacci<1> { enum { value = 1 }; };  
template <> struct Fibonacci<0> { enum { value = 0 }; };
```

```
int main(void)
```

```
{  
    std::cout << "Fibonacci(" << fibnum << ") = ";  
    std::cout << Fibonacci<fibnum>::value;  
    std::cout << std::endl;  
}
```

STL Containers

Performance Comparison

std::vector

std::deque

std::list

Benchmark

Benchmark

```
std::vector<std::string> vec;
```

```
void bench_vector_push_back(int iter) {  
    std::string s("Hello");  
    while (iter--)  
        vec.push_back(s);  
}
```

```
int main()  
{  
    int iter = 3000000;  
    bench_vector_push_back(iter);  
}
```

Benchmark

```
std::vector<std::string> vec;
```

```
void bench_vector_push_back(int iter) {  
    std::string s("Hello");  
    while (iter--)  
        vec.push_back(s);  
}
```

```
int main()  
{  
    int iter = 3000000;  
    bench_vector_push_back(iter);  
}
```

Benchmark

```
std::vector<std::string> vec;  
std::deque<std::string> deq;
```

```
void bench_vector_push_back(int iter) {  
    std::string s("Hello");  
    while (iter--)  
        vec.push_back(s);  
}
```

```
void bench_deque_push_back(int iter) {  
    std::string s("Hello");  
    while (iter--)  
        deq.push_back(s);  
}
```

```
int main()  
{  
    int iter = 3000000;  
    bench_vector_push_back(iter);  
    bench_deque_push_back(iter);  
}
```


Benchmark

```
std::vector<std::string> vec;
std::deque<std::string> deq;
std::list<std::string> lis;

void bench_vector_push_back(int iter) {
    std::string s("Hello");
    while (iter--)
        vec.push_back(s);
}

void bench_deque_push_back(int iter) {
    std::string s("Hello");
    while (iter--)
        deq.push_back(s);
}

void bench_list_push_back(int iter) {
    std::string s("Hello");
    while (iter--)
        lis.push_back(s);
}

int main()
{
    int iter = 3000000;
    bench_vector_push_back(iter);
    bench_deque_push_back(iter);
    bench_list_push_back(iter);
}
```

Benchmark

```
std::vector<std::string> vec;
std::deque<std::string> deq;
std::list<std::string> lis;

void bench_vector_push_back(int iter) {
    std::string s("Hello");
    while (iter--)
        vec.push_back(s);
}

void bench_deque_push_back(int iter) {
    std::string s("Hello");
    while (iter--)
        deq.push_back(s);
}

void bench_list_push_back(int iter) {
    std::string s("Hello");
    while (iter--)
        lis.push_back(s);
}

int main()
{
    int iter = 3000000;
    bench_vector_push_back(iter);
    bench_deque_push_back(iter);
    bench_list_push_back(iter);
}
```

```
$ uftrace record \  
  -d uftrace.data.bench \  
  --nest-libcall \  
  -A malloc@arg1 -R malloc@retval -A free@arg1 \  
  -A memcpy@arg3 -A memmove@arg3 \  
  ./std-string
```

```
$ uftrace record \  
  -d uftrace.data.bench \  
  --nest-libcall \  
  -A malloc@arg1 -R malloc@retval -A free@arg1 \  
  -A memcpy@arg3 -A memmove@arg3 \  
  ./std-string
```

```
$ uftrace graph
```

uftrace graph

- Show function call graph

uftrace graph

**Record 된 데이터를 분석해서
함수 호출 그래프를 출력**

\$ uftrace graph

```
5.321 s : (1) main
2.176 s : +- (1) bench_vector_push_back
1.365 s : | +- (23) std::vector::_M_insert_aux
145.377 us : | | +- (23) operator new
122.596 us : | | | (23) malloc
: | | |
685.339 ms : | | +- (4194326) memcpy
: | | |
2.888 ms : | | +- (22) operator delete
2.857 ms : | | (22) free
: | |
336.277 ms : | +- (2999977) memcpy
: |
726.388 ms : +- (1) bench_deque_push_back
217.685 ms : | +- (2812500) memcpy
: | |
167.695 ms : | +- (187500) std::deque::_M_push_back_aux
101.126 ms : | +- (187515) operator new
60.892 ms : | | (187515) malloc
: | |
14.972 ms : | +- (187500) memcpy
: | |
993.690 us : | +- (15) memmove
: | |
12.357 us : | +- (15) operator delete
5.924 us : | (15) free
: |
2.418 s : +- (1) bench_list_push_back
1.057 s : +- (3000000) operator new
423.438 ms : | (3000000) malloc
: |
230.213 ms : +- (3000000) memcpy
: |
199.812 ms : +- (3000000) std::__detail::_List_node_base::_M_hook
```

\$ uftrace graph

```
5.321 s : (1) main
2.176 s : +- (1) bench_vector_push_back
1.365 s : | +- (23) std::vector::_M_insert_aux
145.377 us : | | +- (23) operator new
122.596 us : | | | (23) malloc
: | | |
685.339 ms : | | +- (4194326) memcpy
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2.888 ms : | | +- (22) operator delete
2.857 ms : | | (22) free
: | |
336.277 ms : | +- (2999977) memcpy
: |
726.388 ms : +- (1) bench_deque_push_back
217.685 ms : | +- (2812500) memcpy
: | |
167.695 ms : | +- (187500) std::deque::_M_push_back_aux
101.126 ms : | +- (187515) operator new
60.892 ms : | | (187515) malloc
: | |
14.972 ms : | +- (187500) memcpy
: | |
993.690 us : | +- (15) memmove
: | |
12.357 us : | +- (15) operator delete
5.924 us : | (15) free
: |
2.418 s : +- (1) bench_list_push_back
1.057 s : +- (3000000) operator new
423.438 ms : | (3000000) malloc
: |
230.213 ms : +- (3000000) memcpy
: |
199.812 ms : +- (3000000) std::__detail::_List_node_base::_M_hook
```

\$ ufttrace graph

```
5.321 s : (1) main
2.176 s : +- (1) bench_vector_push_back
1.365 s : | +- (23) std::vector::_M_insert_aux
145.377 us : | | +- (23) operator new
122.596 us : | | | (23) malloc
: | | |
685.339 ms : | | +- (4194326) memcpy
: | | |
2.888 ms : | | +- (22) operator delete
2.857 ms : | | (22) free
: | |
336.277 ms : | +- (2999977) memcpy
: |
726.388 ms : +- (1) bench_deque_push_back
217.685 ms : | +- (2812500) memcpy
: | |
167.695 ms : | +- (187500) std::deque::_M_push_back_aux
101.126 ms : | +- (187515) operator new
60.892 ms : | | (187515) malloc
: | |
14.972 ms : | +- (187500) memcpy
: | |
993.690 us : | +- (15) memmove
: | |
12.357 us : | +- (15) operator delete
5.924 us : | (15) free
: |
2.418 s : +- (1) bench_list_push_back
1.057 s : +- (3000000) operator new
423.438 ms : | (3000000) malloc
: |
230.213 ms : +- (3000000) memcpy
: |
199.812 ms : +- (3000000) std::__detail::_List_node_base::_M_hook
```


\$ uftrace graph

```
5.321 s : (1) main
2.176 s : +- (1) bench_vector_push_back
1.365 s : | +- (23) std::vector::_M_insert_aux
145.377 us : | | +- (23) operator new
122.596 us : | | | (23) malloc
: | | |
685.339 ms : | | +- (4194326) memcpy
: | | |
2.888 ms : | | +- (22) operator delete
2.857 ms : | | (22) free
: | |
336.277 ms : | +- (2999977) memcpy
: |
726.388 ms : +- (1) bench_deque_push_back
217.685 ms : | +- (2812500) memcpy
: | |
167.695 ms : | +- (187500) std::deque::_M_push_back_aux
101.126 ms : | +- (187515) operator new
60.892 ms : | | (187515) malloc
: | |
14.972 ms : | +- (187500) memcpy
: | |
993.690 us : | +- (15) memmove
: | |
12.357 us : | +- (15) operator delete
5.924 us : | (15) free
: |
2.418 s : +- (1) bench_list_push_back
1.057 s : +- (3000000) operator new
423.438 ms : | (3000000) malloc
: |
230.213 ms : +- (3000000) memcpy
: |
199.812 ms : +- (3000000) std::__detail::_List_node_base::_M_hook
```

\$ uftrace graph

```
5.321 s : (1) main
2.176 s : +- (1) bench_vector_push_back
1.365 s : | +- (23) std::vector::_M_insert_aux
145.377 us : | | +- (23) operator new
122.596 us : | | | (23) malloc
: | | |
685.339 ms : | | +- (4194326) memcpy
: | | |
2.888 ms : | | +- (22) operator delete
2.857 ms : | | (22) free
: | |
336.277 ms : | +- (2999977) memcpy
: |
726.388 ms : +- (1) bench_deque_push_back
217.685 ms : | +- (2812500) memcpy
: | |
167.695 ms : | +- (187500) std::deque::_M_push_back_aux
101.126 ms : | +- (187515) operator new
60.892 ms : | | (187515) malloc
: | |
14.972 ms : | +- (187500) memcpy
: | |
993.690 us : | +- (15) memmove
: | |
12.357 us : | +- (15) operator delete
5.924 us : | (15) free
: |
2.418 s : +- (1) bench_list_push_back
1.057 s : +- (3000000) operator new
423.438 ms : | (3000000) malloc
: |
230.213 ms : +- (3000000) memcpy
: |
199.812 ms : +- (3000000) std::__detail::_List_node_base::_M_hook
```

\$ ufttrace graph

```
5.321 s : (1) main
2.176 s : +- (1) bench_vector_push_back
1.365 s : | +- (23) std::vector::_M_insert_aux
145.377 us : | | +- (23) operator new
122.596 us : | | | (23) malloc
: | | |
685.339 ms : | | +- (4194326) memcpy
: | | |
2.888 ms : | | +- (22) operator delete
2.857 ms : | | (22) free
: | |
336.277 ms : | +- (2999977) memcpy
: |
726.388 ms : +- (1) bench_deque_push_back
217.685 ms : | +- (2812500) memcpy
: | |
167.695 ms : | +- (187500) std::deque::_M_push_back_aux
101.126 ms : | +- (187515) operator new
60.892 ms : | | (187515) malloc
: | |
14.972 ms : | +- (187500) memcpy
: | |
993.690 us : | +- (15) memmove
: | |
12.357 us : | +- (15) operator delete
5.924 us : | (15) free
: |
2.418 s : +- (1) bench_list_push_back
1.057 s : +- (3000000) operator new
423.438 ms : | (3000000) malloc
: |
230.213 ms : +- (3000000) memcpy
: |
199.812 ms : +- (3000000) std::__detail::_List_node_base::_M_hook
```

\$ uftrace graph

```
5.321 s : (1) main
2.176 s : +- (1) bench_vector_push_back
1.365 s : | +- (23) std::vector::_M_insert_aux
145.377 us : | | +- (23) operator new
122.596 us : | | | (23) malloc
: | | |
685.339 ms : | | +- (4194326) memcpy
: | | |
2.888 ms : | | +- (22) operator delete
2.857 ms : | | (22) free
: | |
336.277 ms : | +- (2999977) memcpy
: |
726.388 ms : +- (1) bench_deque_push_back
217.685 ms : | +- (2812500) memcpy
: | |
167.695 ms : | +- (187500) std::deque::_M_push_back_aux
101.126 ms : | +- (187515) operator new
60.892 ms : | | (187515) malloc
: | |
14.972 ms : | +- (187500) memcpy
: | |
993.690 us : | +- (15) memmove
: | |
12.357 us : | +- (15) operator delete
5.924 us : | (15) free
: |
2.418 s : +- (1) bench_list_push_back
1.057 s : +- (3000000) operator new
423.438 ms : | (3000000) malloc
: |
230.213 ms : +- (3000000) memcpy
: |
199.812 ms : +- (3000000) std::__detail::_List_node_base::_M_hook
```

원본 버퍼의 내용을
새로운 버퍼로 복사하는데
필요한 memcpy

새로 들어온 string 을
push_back 해서
발생하는 memcpy

uftrace replay

시간 순서대로 출력해서 다시 확인

bench_vector_push_back

std::vector<std::string>

```
$ uftrace replay
```

```
    ...  
[121878] | main() {  
[121878] |     bench_vector_push_back() {  
    ...
```

std::vector push_back

\$ uftrace replay

```
...
[121878] | main() {
[121878] |   bench_vector_push_back() {
[121878] |     std::vector::_M_insert_aux() {
[121878] |       operator new() {
3.533 us [121878] |         malloc(32) = 0xdc6550;
4.200 us [121878] |       } /* operator new */
2.006 us [121878] |       memcpy(5);
7.777 us [121878] |     } /* std::vector::_M_insert_aux */
...

```

std::vector push_back

\$ uftrace replay

```
...
[121878] | main() {
[121878] |   bench_vector_push_back() {
[121878] |     std::vector::_M_insert_aux() {
[121878] |       operator new() {
3.533 us [121878] |         malloc(32) = 0xdc6550;
4.200 us [121878] |       } /* operator new */
2.006 us [121878] |       memcpy(5);
7.777 us [121878] |     } /* std::vector::_M_insert_aux */
[121878] |     std::vector::_M_insert_aux() {
[121878] |       operator new() {
0.227 us [121878] |         malloc(64) = 0xdc6580;
0.780 us [121878] |       } /* operator new */
0.250 us [121878] |       memcpy(5);
0.160 us [121878] |       memcpy(5);
[121878] |     }
1.813 us [121878] |     operator delete() {
[121878] |       free(0xdc6550);
3.460 us [121878] |     } /* operator delete */
6.370 us [121878] |   } /* std::vector::_M_insert_aux */
...

```

std::vector push_back

\$ uftrace replay

```
...
[121878] | main() {
[121878] |     bench_vector_push_back() {
[121878] |         std::vector::_M_insert_aux() {
[121878] |             operator new() {
3.533 us [121878] |                 malloc(32) = 0xdc6550;
4.200 us [121878] |             } /* operator new */
2.006 us [121878] |             memcpy(5);
7.777 us [121878] |         } /* std::vector::_M_insert_aux */
[121878] |         std::vector::_M_insert_aux() {
[121878] |             operator new() {
0.227 us [121878] |                 malloc(64) = 0xdc6580;
0.780 us [121878] |             } /* operator new */
0.250 us [121878] |             memcpy(5);
0.160 us [121878] |             memcpy(5);
[121878] |             operator delete() {
1.813 us [121878] |                 free(0xdc6550);
3.460 us [121878] |             } /* operator delete */
6.370 us [121878] |         } /* std::vector::_M_insert_aux */
[121878] |         std::vector::_M_insert_aux() {
[121878] |             operator new() {
0.244 us [121878] |                 malloc(128) = 0xdc65d0;
0.743 us [121878] |             } /* operator new */
0.186 us [121878] |             memcpy(5);
0.160 us [121878] |             memcpy(5);
0.160 us [121878] |             memcpy(5);
[121878] |             operator delete() {
0.320 us [121878] |                 free(0xdc6580);
0.897 us [121878] |             } /* operator delete */
3.737 us [121878] |         } /* std::vector::_M_insert_aux */
...
```

std::vector push_back

\$ uftrace replay

```
...
[121878] | main() {
[121878] |     bench_vector_push_back() {
[121878] |         std::vector::_M_insert_aux() {
[121878] |             operator new() {
3.533 us [121878] |                 malloc(32) = 0xdc6550;
4.200 us [121878] |             } /* operator new */
2.006 us [121878] |             memcpy(5);
7.777 us [121878] |         } /* std::vector::_M_insert_aux */
[121878] |         std::vector::_M_insert_aux() {
[121878] |             operator new() {
0.227 us [121878] |                 malloc(64) = 0xdc6580;
0.780 us [121878] |             } /* operator new */
0.250 us [121878] |             memcpy(5);
0.160 us [121878] |             memcpy(5);
[121878] |             operator delete() {
1.813 us [121878] |                 free(0xdc6550);
3.460 us [121878] |             } /* operator delete */
6.370 us [121878] |         } /* std::vector::_M_insert_aux */
[121878] |         std::vector::_M_insert_aux() {
[121878] |             operator new() {
0.244 us [121878] |                 malloc(128) = 0xdc65d0;
0.743 us [121878] |             } /* operator new */
0.186 us [121878] |             memcpy(5);
0.160 us [121878] |             memcpy(5);
0.160 us [121878] |             memcpy(5);
[121878] |             operator delete() {
0.320 us [121878] |                 free(0xdc6580);
0.897 us [121878] |             } /* operator delete */
3.737 us [121878] |         } /* std::vector::_M_insert_aux */
0.167 us [121878] |         memcpy(5);
...
```

원본 버퍼의 내용을
새로운 버퍼로 복사하는데
필요한 memcpy

새로 들어온 string 을
push_back 해서
발생하는 memcpy

std::vector push_back

```

...
[121878] | bench_vector_push_back() {
...
[121878] |     std::vector::_M_insert_aux() {
[121878] |         operator new() {
0.244 us [121878] |             malloc(128) = 0xdc65d0;
0.743 us [121878] |         } /* operator new */
0.186 us [121878] |         memcpy(5);
0.160 us [121878] |         memcpy(5);
0.160 us [121878] |         memcpy(5);
[121878] |         operator delete() {
0.320 us [121878] |             free(0xdc6580);
0.897 us [121878] |         } /* operator delete */
3.737 us [121878] |     } /* std::vector::_M_insert_aux */
0.167 us [121878] |     memcpy(5);
[121878] |     std::vector::_M_insert_aux() {
[121878] |         operator new() {
0.220 us [121878] |             malloc(256) = 0xdc6660;
0.693 us [121878] |         } /* operator new */
0.164 us [121878] |         memcpy(5);
0.157 us [121878] |         memcpy(5);
0.157 us [121878] |         memcpy(5);
0.154 us [121878] |         memcpy(5);
0.157 us [121878] |         memcpy(5);
[121878] |         operator delete() {
0.407 us [121878] |             free(0xdc65d0);
0.854 us [121878] |         } /* operator delete */
4.256 us [121878] |     } /* std::vector::_M_insert_aux */
0.157 us [121878] |     memcpy(5);
0.157 us [121878] |     memcpy(5);
0.157 us [121878] |     memcpy(5);
[121878] |     std::vector::_M_insert_aux() {
[121878] |         operator new() {
0.520 us [121878] |             malloc(512) = 0xdc6770;
1.000 us [121878] |         } /* operator new */
0.154 us [121878] |         memcpy(5);
...

```

원본 버퍼의 내용을
새로운 버퍼로 복사하는데
필요한 memcpy의
횟수가 증가함

std::vector push_back

```

...
[121878] | bench_vector_push_back() {
...
[121878] |     std::vector::_M_insert_aux() {
[121878] |         operator new() {
1.040 us [121878] |             malloc(1024) = 0xdc6980;
1.510 us [121878] |         } /* operator new */
0.157 us [121878] |         memcpy(5);
0.157 us [121878] |         memcpy(5);
0.156 us [121878] |         memcpy(5);
0.157 us [121878] |         memcpy(5);
0.154 us [121878] |         memcpy(5);
0.153 us [121878] |         memcpy(5);
0.150 us [121878] |         memcpy(5);
0.150 us [121878] |         memcpy(5);
0.157 us [121878] |         memcpy(5);
0.153 us [121878] |         memcpy(5);
0.153 us [121878] |         memcpy(5);
0.153 us [121878] |         memcpy(5);
0.146 us [121878] |         memcpy(5);
0.150 us [121878] |         memcpy(5);
0.154 us [121878] |         memcpy(5);
0.157 us [121878] |         memcpy(5);
0.156 us [121878] |         memcpy(5);
[121878] |         operator delete() {
0.274 us [121878] |             free(0xdc6770);
0.700 us [121878] |         } /* operator delete */
9.369 us [121878] |     } /* std::vector::_M_insert_aux */
0.157 us [121878] |     memcpy(5);
0.170 us [121878] |     memcpy(5);
0.160 us [121878] |     memcpy(5);
...

```

원본 버퍼의 내용을
새로운 버퍼로 복사하는데
필요한 memcpy의
횟수가 크게 증가함

새로 들어온 string을
push_back 해서
발생하는 memcpy는
일정한 횟수

std::vector push_back

bench_deque_push_back

std::deque<std::string>

\$ uftrace replay

```
...
[121878] | bench_deque_push_back() {
0.083 us [121878] |     memcpy(5);
0.080 us [121878] |     memcpy(5);
0.077 us [121878] |     memcpy(5);
0.078 us [121878] |     memcpy(5);
0.079 us [121878] |     memcpy(5);
0.079 us [121878] |     memcpy(5);
0.076 us [121878] |     memcpy(5);
0.076 us [121878] |     memcpy(5);
0.076 us [121878] |     memcpy(5);
0.080 us [121878] |     memcpy(5);
0.074 us [121878] |     memcpy(5);
0.078 us [121878] |     memcpy(5);
0.077 us [121878] |     memcpy(5);
0.079 us [121878] |     memcpy(5);
0.080 us [121878] |     memcpy(5);
[121878] |     std::deque::_M_push_back_aux() {
[121878] |         operator new() {
4.682 us [121878] |             malloc(512) = 0xdc6550;
6.328 us [121878] |         } /* operator new */
0.085 us [121878] |         memcpy(5);
7.552 us [121878] |     } /* std::deque::_M_push_back_aux */
0.074 us [121878] |     memcpy(5);
0.080 us [121878] |     memcpy(5);
0.080 us [121878] |     memcpy(5);
0.083 us [121878] |     memcpy(5);
0.077 us [121878] |     memcpy(5);
```

...

std::deque push_back

\$ uftrace replay

```
...
[121878] | bench_deque_push_back() {
0.083 us [121878] |     memcpy(5);
0.080 us [121878] |     memcpy(5);
0.077 us [121878] |     memcpy(5);
0.078 us [121878] |     memcpy(5);
0.079 us [121878] |     memcpy(5);
0.079 us [121878] |     memcpy(5);
0.076 us [121878] |     memcpy(5);
0.076 us [121878] |     memcpy(5);
0.076 us [121878] |     memcpy(5);
0.080 us [121878] |     memcpy(5);
0.074 us [121878] |     memcpy(5);
0.078 us [121878] |     memcpy(5);
0.077 us [121878] |     memcpy(5);
0.079 us [121878] |     memcpy(5);
0.080 us [121878] |     memcpy(5);
[121878] |     std::deque::_M_push_back_aux() {
[121878] |         operator new() {
4.682 us [121878] |             malloc(512) = 0xdc6550;
6.328 us [121878] |         } /* operator new */
0.085 us [121878] |         memcpy(5);
7.552 us [121878] |     } /* std::deque::_M_push_back_aux */
0.074 us [121878] |     memcpy(5);
0.080 us [121878] |     memcpy(5);
0.080 us [121878] |     memcpy(5);
0.083 us [121878] |     memcpy(5);
0.077 us [121878] |     memcpy(5);
...
```

미리 할당된 chunk 버퍼에 push_back

15 번의 memcpy 호출:
32 bytes (std::string 의 크기) * 15
= 한 버퍼에서 480 바이트가 소모됨

추가적인
chunk
할당

std::deque push_back

\$ uftrace replay

```
...
[121878] | bench_deque_push_back() {
...
[121878] |     std::deque::_M_push_back_aux() {
[121878] |         operator new() {
4.682 us [121878] |             malloc(512) = 0xdc6550;
6.328 us [121878] |         } /* operator new */
0.085 us [121878] |         memcpy(5);
7.552 us [121878] |     } /* std::deque::_M_push_back_aux */
0.074 us [121878] |     memcpy(5);
0.080 us [121878] |     memcpy(5);
0.080 us [121878] |     memcpy(5);
0.083 us [121878] |     memcpy(5);
0.077 us [121878] |     memcpy(5);
0.079 us [121878] |     memcpy(5);
0.075 us [121878] |     memcpy(5);
0.078 us [121878] |     memcpy(5);
0.075 us [121878] |     memcpy(5);
0.077 us [121878] |     memcpy(5);
0.077 us [121878] |     memcpy(5);
0.077 us [121878] |     memcpy(5);
0.079 us [121878] |     memcpy(5);
0.080 us [121878] |     memcpy(5);
0.078 us [121878] |     memcpy(5);
[121878] |     std::deque::_M_push_back_aux() {
[121878] |         operator new() {
0.305 us [121878] |             malloc(512) = 0xdc6760;
0.882 us [121878] |         } /* operator new */
0.079 us [121878] |         memcpy(5);
1.256 us [121878] |     } /* std::deque:: M push back aux */
```

std::deque push_back

bench_list_push_back

std::list<std::string>

\$ uftrace replay

```
...
[121878] | bench_list_push_back() {
[121878] |     operator new() {
0.450 us [121878] |         malloc(48) = 0xdc62f0;
0.677 us [121878] |     } /* operator new */
0.080 us [121878] |     memcpy(5);
5.139 us [121878] |     std::__detail::_List_node_base::_M_hook();
[121878] |     operator new() {
0.240 us [121878] |         malloc(48) = 0xfd2580;
0.480 us [121878] |     } /* operator new */
0.083 us [121878] |     memcpy(5);
0.080 us [121878] |     std::__detail::_List_node_base::_M_hook();
[121878] |     operator new() {
0.400 us [121878] |         malloc(48) = 0xdca0a0;
0.641 us [121878] |     } /* operator new */
0.085 us [121878] |     memcpy(5);
0.071 us [121878] |     std::__detail::_List_node_base::_M_hook();
[121878] |     operator new() {
0.251 us [121878] |         malloc(48) = 0x1cac6d0;
0.479 us [121878] |     } /* operator new */
0.075 us [121878] |     memcpy(5);
0.069 us [121878] |     std::__detail::_List_node_base::_M_hook();
[121878] |     operator new() {
0.304 us [121878] |         malloc(48) = 0xdc8200;
0.511 us [121878] |     } /* operator new */
0.076 us [121878] |     memcpy(5);
0.066 us [121878] |     std::__detail::_List_node_base::_M_hook();
...
```

32 bytes of std::string
+ 8 bytes of pointer * 2

size of "Hello"

std::list push_back

```
$ uftrace graph bench_list_push_back
```

```
#
```

```
# function graph for 'bench_list_push_back' (session: 53a12394b0ce1367)
```

```
#
```

```
backtrace
```

```
=====
```

```
backtrace #0: hit 1, time 2.418 s
```

```
[0] main (0x400cc9)
```

```
[1] bench_list_push_back (0x401044)
```

```
calling functions
```

```
=====
```

```
2.418 s : (1) bench_list_push_back
```

```
1.057 s : +-(3000000) operator new
```

```
423.438 ms : | (3000000) malloc
```

```
: |
```

```
230.213 ms : +-(3000000) memcpy
```

```
: |
```

```
199.812 ms : +-(3000000) std::__detail::_List_node_base::_M_hook
```

std::list push_back

uftrace tui

Text User Interface

TUI: Text User Interface

```
$ man uftrace tui
```

UFTRACE-TUI(1)

UFTRACE-TUI(1)

NAME

uftrace-tui - (Interactive) Text-based User Interface

SYNOPSIS

uftrace tui [options]

DESCRIPTION

This command starts an interactive window on a terminal which can show same output of other commands like graph, report and info. Users can navigate the result easily with key presses. The command line options are used to limit the initial data loading.

OPTIONS

-F FUNC, --filter=FUNC

Set filter to trace selected functions only. This option can be used more than once. See uftrace-replay(1) for an explanation of filters.

...

TUI: Text User Interface

```
$ uftrace record -a ./clang hello.c
```

```
$ uftrace tui -t 1ms
```

Key uftrace command

G call Graph for session #1: clang-6.0
call Graph for session #2: clang-6.0
call Graph for session #3: x86_64-linux-gnu-ld.bfd
R Report functions
I uftrace Info
h Help message
q quit

Key uftrace command

```
G  call Graph for session #1: clang-6.0
   call Graph for session #2: clang-6.0
   call Graph for session #3: x86_64-linux-gnu-ld.bfd
R  Report functions
I  uftrace Info
h  Help message
q  quit
```

Help: (press any key to exit)

ARROW	Navigation
PgUp/Dn	
Home/End	
Enter	Select/Fold
G	Show (full) call graph
g	Show call graph for this function
R	Show uftrace report
I	Show uftrace info
S	Change session
O	Open editor
c/e	Collapse/Expand graph
n/p	Next/Prev sibling
u	Move up to parent
l	Move to the longest executed child
j/k	Move down/up
/	Search
</>/N/P	Search next/prev
v	Show debug message
h/?	Show this help
q	Quit

Key uftrace command

G call Graph for session #1: clang-6.0
call Graph for session #2: clang-6.0
call Graph for session #3: x86_64-linux-gnu-ld.bfd
R Report functions
I uftrace Info
h Help message
q quit

uftrace info

system information

=====

program version : v0.8.3-326-g480f0
recorded on : Thu Aug 2 14:52:13 2018
cmdline : uftrace record -a clang /home/honggyu/hello.c
cpu info : Intel(R) Xeon(R) CPU E5-2630 v4 @ 2.20GHz
number of cpus : 40 / 40 (online / possible)
memory info : 9.6 / 62.5 GB (free / total)
system load : 9.35 / 11.69 / 9.99 (1 / 5 / 15 min)
kernel version : Linux 4.4.0-116-generic
hostname : intel20
distro : "Ubuntu 16.04.3 LTS"

#

process information

=====

number of tasks : 3
task list : 153294(clang), 153315(clang-6.0), 153324(ld)
exe image : /home/honggyu/work/llvm/release/build.release.g.pg/bin/clang-6.0
auto-args : true
pattern : regex
exit status : exited with code: 0
elapsed time : 36.550426950 sec
cpu time : 0.636 / 35.836 sec (sys / user)
context switch : 16 / 55 (voluntary / involuntary)
max rss : 1325216 KB
page fault : 3 / 239746 (major / minor)
disk iops : 264 / 19448 (read / write)

Key uftrace command

```
G call Graph for session #1: clang-6.0  
  call Graph for session #2: clang-6.0  
  call Graph for session #3: x86_64-linux-gnu-ld.bfd
```

R Report functions

```
I uftrace Info  
h Help message  
q quit
```

Total Time	Self Time	Calls	Function
37.986 s	29.594 us	3	llvm::raw_ostream::operator<<
19.623 s	3.287 ms	2	main
18.993 s	217.431 us	1	clang::driver::Driver::ExecuteCompilation
18.993 s	21.904 us	2	llvm::yaml::Scanner::scanTag
18.993 s	957.012 us	2	llvm::IRBuilderBase::CreateBinaryIntrinsic
18.992 s	15.747 us	2	llvm::sys::Wait
18.992 s	18.992 s	2	waitpid
567.307 ms	292.219 us	1	ccl_main
552.319 ms	84.215 us	1	clang::CodeGen::CodeGenFunction::EmitOMPSimdFinal
552.235 ms	459.279 us	1	clang::CompilerInstance::ExecuteAction
537.654 ms	3.276 us	1	clang::FrontendAction::Execute
537.651 ms	0.814 us	1	clang::CodeGenAction::ExecuteAction
537.650 ms	211.023 us	1	clang::ASTFrontendAction::ExecuteAction
537.439 ms	179.817 ms	1	clang::ParseAST
203.407 ms	111.046 us	100	clang::Parser::ParseTopLevelDecl
203.296 ms	153.751 us	102	llvm::WriteThinLinkBitcodeToFile
157.805 ms	68.595 ms	76	llvm::ValueEnumerator::OptimizeConstants
140.190 ms	140.190 ms	1	xexit
131.668 ms	291.452 us	79	clang::Parser::ParseDeclarationOrFunctionDefinition
131.377 ms	19.252 ms	79	clang::Parser::ParseDeclOrFunctionDefInternal
128.702 ms	103.632 ms	28	clang::Preprocessor::Lex
75.820 ms	22.581 us	22	clang::Parser::ExpectAndConsumeSemi
73.558 ms	295.771 us	1	clang::BackendConsumer::HandleTranslationUnit
73.262 ms	3.986 ms	1	clang::EmitBackendOutput
71.474 ms	63.913 us	21	clang::Parser::ParseDeclaration
71.410 ms	5.187 ms	21	std::__introsort_loop
50.500 ms	486.983 us	1	llvm::WriteBitcodeToFile
48.032 ms	0.953 us	1	llvm::legacy::PassManager::run
48.031 ms	539.554 us	1	std::vector::_M_range_insert
43.342 ms	8.545 us	2	llvm::sys::fs::createTemporaryFile
41.484 ms	388.087 us	2	llvm::FPPassManager::runOnModule
41.096 ms	6.050 ms	3	llvm::FPPassManager::runOnFunction
34.868 ms	155.527 us	3	clang::driver::createDriverOptTable
32.407 ms	225.644 us	1	clang::driver::Driver::BuildCompilation
27.129 ms	84.861 us	3	clang::Preprocessor::EnterSourceFile
27.044 ms	6.210 us	3	clang::SrcMgr::ContentCache::getBuffer
27.038 ms	83.267 us	3	clang::FileManager::getBufferForFile
26.955 ms	5.154 us	3	_GLOBAL__N_1::RealFile::getBuffer
26.950 ms	5.760 us	3	llvm::MemoryBuffer::getOpenFile
26.944 ms	34.826 us	3	llvm::DICompileUnit::getEmissionKind
26.909 ms	26.909 ms	3	pread
26.742 ms	38.983 us	1	std::vector::_M_realloc_insert
26.703 ms	60.510 us	1	llvm::X86TargetMachine::getSubtargetImpl
26.642 ms	411.204 us	1	llvm::X86Subtarget::X86Subtarget
25.317 ms	14.310 us	1	llvm::sys::path::stem
25.302 ms	35.562 us	2	llvm::sys::Process::GetArgumentVector
25.284 ms	270.026 us	2	llvm::sys::ProcessInfo::ProcessInfo
25.059 ms	4.691 us	6	clang::Lexer::Lex

Key uftrace command

G call Graph for session #1: clang-6.0
call Graph for session #2: clang-6.0
call Graph for session #3: x86_64-linux-gnu-ld.bfd
R Report functions
I uftrace Info
h Help message
q quit

TOTAL TIME : FUNCTION

570.475 ms : (1) clang-6.0

570.475 ms : (1) main

567.307 ms : (1) cc1_main

14.695 ms : (1) clang::CompilerInvocation::CreateFromArgs

11.412 ms : (1) clang::driver::createDriverOptTable

3.349 ms : (1) llvm::opt::OptTable::OptTable

7.999 ms : (2) llvm::opt::OptTable::addValues

2.226 ms : (1) llvm::opt::OptTable::ParseArgs

1.237 ms : (1) llvm::opt::OptTable::ParseOneArg

552.319 ms : (1) clang::CodeGen::CodeGenFunction::EmitOMPSimdFinal

552.235 ms : (1) clang::CompilerInstance::ExecuteAction

14.121 ms : (1) clang::DiagnosticConsumer::~~DiagnosticConsumer

3.127 ms : (1) llvm::InnerLoopVectorizer::widenInstruction

2.381 ms : (1) clang::vfs::recursive_directory_iterator::recursive_directory_iterator

2.346 ms : (1) clang::vfs::File::~~File

10.437 ms : (1) clang::Builtin::Context::initializeBuiltins

537.654 ms : (1) clang::FrontendAction::Execute

537.651 ms : (1) clang::CodeGenAction::ExecuteAction

537.650 ms : (1) clang::ASTFrontendAction::ExecuteAction

537.439 ms : (1) clang::ParseAST

14.959 ms : (1) clang::Preprocessor::EnterMainSourceFile

14.907 ms : (1) clang::Preprocessor::EnterSourceFile

14.870 ms : (1) clang::SrcMgr::ContentCache::getBuffer

14.867 ms : (1) clang::FileManager::getBufferForFile

14.832 ms : (1) _GLOBAL__N_1::RealFile::getBuffer

14.830 ms : (1) llvm::MemoryBuffer::getOpenFile

14.828 ms : (1) llvm::DICompileUnit::getEmissionKind

14.816 ms : (1) pread

50.500 ms : (1) llvm::WriteBitcodeToFile

50.013 ms : (1) clang::Preprocessor::Lex

9.395 ms : (1) clang::Lexer::Lex

9.394 ms : (1) clang::ento::registerStreamChecker

9.394 ms : (1) clang::Preprocessor::HandleDirective

9.384 ms : (1) clang::ento::registerCStringSyntaxChecker

9.157 ms : (1) clang::Preprocessor::EnterSourceFile

9.133 ms : (1) clang::SrcMgr::ContentCache::getBuffer

9.131 ms : (1) clang::FileManager::getBufferForFile

9.107 ms : (1) _GLOBAL__N_1::RealFile::getBuffer

9.105 ms : (1) llvm::MemoryBuffer::getOpenFile

9.103 ms : (1) llvm::DICompileUnit::getEmissionKind

9.092 ms : (1) pread

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:	
552.319 ms	(1) clang
552.235 ms	(1) clang
14.121 ms	(1) cl
3.127 ms	(1) PgUp/Dn
2.381 ms	(1) Home/End
2.346 ms	(1) Enter
:	
10.437 ms	(1) g
:	
537.654 ms	(1) cl
537.651 ms	(1) cl
537.650 ms	(1) cl
537.439 ms	(1) cl
14.959 ms	(1) n/p
14.907 ms	(1) u
14.870 ms	(1) 1
14.867 ms	(1) j/k
14.832 ms	(1) /
14.830 ms	(1) </>/N/P
14.828 ms	(1) v
14.816 ms	(1) h/?
:	
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9.395 ms	(1) clang::Lexer::Lex
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9.092 ms	(1) pread
:	

Help: (press any key to exit)

ARROW

Navigation

PgUp/Dn

Home/End

Enter

Select/Fold

G

Show (full) call graph

g

Show call graph for this function

R

Show uftrace report

I

Show uftrace info

S

Change session

O

Open editor

c/e

Collapse/Expand graph

n/p

Next/Prev sibling

u

Move up to parent

1

Move to the longest executed child

j/k

Move down/up

/

Search

</>/N/P

Search next/prev

v

Show debug message

h/?

Show this help

q

Quit

erator

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9.092 ms : |    (1) pread
:
2.586 ms : |    |-(1) llvm::BitcodeWriter::writeThinLinkBitcode
2.582 ms : |    (1) clang::Parser::ParseTopLevelDecl
2.581 ms : |    (1) llvm::WriteThinLinkBitcodeToFile
2.568 ms : |    (1) clang::Parser::ParseDeclaration
2.555 ms : |    (1) std::__introsort_loop
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14.907 ms	(1) clang::Preprocessor::EnterSourceFile
14.870 ms	(1) clang::SrcMgr::ContentCache::getBuffer
14.867 ms	(1) clang::FileManager::getBufferForFile
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50.500 ms	└─(1) llvm::WriteBitcodeToFile
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9.092 ms	(1) pread
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2.582 ms	(1) clang::Parser::ParseTopLevelDecl
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TOTAL TIME : FUNCTION

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537.654 ms : |      |-(1) clang::FrontendAction::Execute
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:
200.824 ms : |      |-(99) clang::Parser::ParseTopLevelDecl
200.715 ms : |      (99) llvm::WriteThinLinkBitcodeToFile
68.905 ms : |      |-(20) clang::Parser::ParseDeclaration
```

TOTAL TIME : FUNCTION

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570.475 ms : (1) clang-6.0
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9.394 ms : |-(1) clang::Preprocessor::HandleDirective
9.384 ms : |-(1) clang::ento::registerCStringSyntaxChecker
9.157 ms : |-(1) clang::Preprocessor::EnterSourceFile
9.133 ms : |-(1) clang::SrcMgr::ContentCache::getBuffer
9.131 ms : |-(1) clang::FileManager::getBufferForFile
9.107 ms : |-(1) _GLOBAL__N_1::RealFile::getBuffer
9.105 ms : |-(1) llvm::MemoryBuffer::getOpenFile
9.103 ms : |-(1) llvm::DICompileUnit::getEmissionKind
9.092 ms : |-(1) pread
:
2.586 ms : |-(1) llvm::BitcodeWriter::writeThinLinkBitcode
2.582 ms : |-(1) clang::Parser::ParseTopLevelDecl
2.581 ms : |-(1) llvm::WriteThinLinkBitcodeToFile
2.568 ms : |-(1) clang::Parser::ParseDeclaration
2.555 ms : |-(1) std::__introsort_loop
2.482 ms : |-(1) llvm::ValueEnumerator::OptimizeConstants
2.233 ms : |-(1) clang::Parser::ExpectAndConsumeSemi
2.231 ms : |-(1) clang::Preprocessor::Lex
:
200.824 ms : |-(99) clang::Parser::ParseTopLevelDecl
200.715 ms : |-(99) llvm::WriteThinLinkBitcodeToFile
68.905 ms : |-(20) clang::Parser::ParseDeclaration
```

TOTAL TIME : FUNCTION

```
570.475 ms : (1) clang-6.0
570.475 ms : (1) main
567.307 ms : |-(1) cc1_main
14.695 ms : |  └─▶(1) clang::CompilerInvocation::CreateFromArgs
:
552.319 ms : |      |-(1) clang::CodeGen::CodeGenFunction::EmitOMPSimdFinal
552.235 ms : |      (1) clang::CompilerInstance::ExecuteAction
14.121 ms : |      |  └─▶(1) clang::DiagnosticConsumer::~~DiagnosticConsumer
:
537.654 ms : |      |-(1) clang::FrontendAction::Execute
537.651 ms : |      (1) clang::CodeGenAction::ExecuteAction
537.650 ms : |      (1) clang::ASTFrontendAction::ExecuteAction
537.439 ms : |      (1) clang::ParseAST
14.959 ms : |      |-(1) clang::Preprocessor::EnterMainSourceFile
14.907 ms : |      (1) clang::Preprocessor::EnterSourceFile
14.870 ms : |      (1) clang::SrcMgr::ContentCache::getBuffer
14.867 ms : |      (1) clang::FileManager::getBufferForFile
14.832 ms : |      (1) _GLOBAL__N_1::RealFile::getBuffer
14.830 ms : |      (1) llvm::MemoryBuffer::getOpenFile
14.828 ms : |      (1) llvm::DICompileUnit::getEmissionKind
14.816 ms : |      (1) pread
:
50.500 ms : |      |-(1) llvm::WriteBitcodeToFile
50.013 ms : |      (1) clang::Preprocessor::Lex
9.395 ms : |      (1) clang::Lexer::Lex
9.394 ms : |      (1) clang::ento::registerStreamChecker
9.394 ms : |      (1) clang::Preprocessor::HandleDirective
9.384 ms : |      (1) clang::ento::registerCStringSyntaxChecker
9.157 ms : |      (1) clang::Preprocessor::EnterSourceFile
9.133 ms : |      (1) clang::SrcMgr::ContentCache::getBuffer
9.131 ms : |      (1) clang::FileManager::getBufferForFile
9.107 ms : |      (1) _GLOBAL__N_1::RealFile::getBuffer
9.105 ms : |      (1) llvm::MemoryBuffer::getOpenFile
9.103 ms : |      (1) llvm::DICompileUnit::getEmissionKind
9.092 ms : |      (1) pread
:
2.586 ms : |      |-(1) llvm::BitcodeWriter::writeThinLinkBitcode
2.582 ms : |      (1) clang::Parser::ParseTopLevelDecl
2.581 ms : |      (1) llvm::WriteThinLinkBitcodeToFile
2.568 ms : |      (1) clang::Parser::ParseDeclaration
2.555 ms : |      (1) std::__introsort_loop
2.482 ms : |      (1) llvm::ValueEnumerator::OptimizeConstants
2.233 ms : |      (1) clang::Parser::ExpectAndConsumeSemi
2.231 ms : |      (1) clang::Preprocessor::Lex
:
200.824 ms : |-(99) clang::Parser::ParseTopLevelDecl
200.715 ms : |      (99) llvm::WriteThinLinkBitcodeToFile
68.905 ms : |      |-(20) clang::Parser::ParseDeclaration
```

TOTAL TIME : FUNCTION

```
570.475 ms : (1) clang-6.0
570.475 ms : (1) main
567.307 ms : └─(1) cc1_main
14.695 ms :   └─▶(1) clang::CompilerInvocation::CreateFromArgs
      :
552.319 ms :   └─(1) clang::CodeGen::CodeGenFunction::EmitOMPSimdFinal
552.235 ms :   (1) clang::CompilerInstance::ExecuteAction
14.121 ms :     └─▶(1) clang::DiagnosticConsumer::~~DiagnosticConsumer
      :
537.654 ms :     └─(1) clang::FrontendAction::Execute
537.651 ms :       (1) clang::CodeGenAction::ExecuteAction
537.650 ms :       (1) clang::ASTFrontendAction::ExecuteAction
537.439 ms : (1) clang::ParseAST
14.959 ms : └─(1) clang::Preprocessor::EnterMainSourceFile
14.907 ms :   (1) clang::Preprocessor::EnterSourceFile
14.870 ms :   (1) clang::SrcMgr::ContentCache::getBuffer
14.867 ms :   (1) clang::FileManager::getBufferForFile
14.832 ms :   (1) _GLOBAL__N_1::RealFile::getBuffer
14.830 ms :   (1) llvm::MemoryBuffer::getOpenFile
14.828 ms :   (1) llvm::DICompileUnit::getEmissionKind
14.816 ms :   (1) pread
      :
50.500 ms : └─(1) llvm::WriteBitcodeToFile
50.013 ms :   (1) clang::Preprocessor::Lex
9.395 ms :   (1) clang::Lexer::Lex
9.394 ms :   (1) clang::ento::registerStreamChecker
9.394 ms :   (1) clang::Preprocessor::HandleDirective
9.384 ms :   (1) clang::ento::registerCStringSyntaxChecker
9.157 ms :   (1) clang::Preprocessor::EnterSourceFile
9.133 ms :   (1) clang::SrcMgr::ContentCache::getBuffer
9.131 ms :   (1) clang::FileManager::getBufferForFile
9.107 ms :   (1) _GLOBAL__N_1::RealFile::getBuffer
9.105 ms :   (1) llvm::MemoryBuffer::getOpenFile
9.103 ms :   (1) llvm::DICompileUnit::getEmissionKind
9.092 ms :   (1) pread
      :
2.586 ms : └─(1) llvm::BitcodeWriter::writeThinLinkBitcode
2.582 ms :   (1) clang::Parser::ParseTopLevelDecl
2.581 ms :   (1) llvm::WriteThinLinkBitcodeToFile
2.568 ms :   (1) clang::Parser::ParseDeclaration
2.555 ms :   (1) std::__introsort_loop
2.482 ms :   (1) llvm::ValueEnumerator::OptimizeConstants
2.233 ms :   (1) clang::Parser::ExpectAndConsumeSemi
2.231 ms :   (1) clang::Preprocessor::Lex
      :
200.824 ms : └─(99) clang::Parser::ParseTopLevelDecl
200.715 ms :   (99) llvm::WriteThinLinkBitcodeToFile
68.905 ms : └─(20) clang::Parser::ParseDeclaration
```



```

570.475 ms : (1) clang-6.0
570.475 ms : (1) main
567.307 ms : |-(1) cc1_main
  14.695 ms : |  ►(1) clang::CompilerInvocation::CreateFromArgs
    :      :
552.319 ms : |      |-(1) clang::CodeGen::CodeGenFunction::EmitOMPsimdFinal
552.235 ms : |      |-(1) clang::CompilerInstance::ExecuteAction
  14.121 ms : |      |  ►(1) clang::DiagnosticConsumer::~DiagnosticConsumer
    :      :
537.654 ms : |      |-(1) clang::FrontendAction::Execute
537.651 ms : |      |  (1) clang::CodeGenAction::ExecuteAction
537.650 ms : |      |  (1) clang::ASTFrontendAction::ExecuteAction
537.439 ms : |      |  (1) clang::ParseAST
  14.959 ms : |      |  ►(1) clang::Preprocessor::EnterMainSourceFile
    :      :
50.500 ms : |      |  ►(1) llvm::WriteBitcodeToFile
    :      :
  2.586 ms : |      |  ►(1) llvm::BitcodeWriter::writeThinLinkBitcode
    :      :

```

```

200.824 ms : |-(99) clang::Parser::ParseTopLevelDecl
200.715 ms : |-(99) llvm::WriteThinLinkBitcodeToFile
68.905 ms : |-(20) clang::Parser::ParseDeclaration
68.854 ms : |-(20) std::__introsort_loop
54.947 ms : |-(15) llvm::ValueEnumerator::OptimizeConstants
52.464 ms : |-(14) clang::Parser::ExpectAndConsumeSemi
52.451 ms : |-(14) clang::Preprocessor::Lex
22.955 ms : |-(4) clang::Preprocessor::CachingLex
22.943 ms : |-(4) clang::Preprocessor::Lex
11.436 ms : |-(3) clang::Lexer::Lex
11.434 ms : |-(3) clang::ento::registerStreamChecker
11.408 ms : |-(3) clang::Preprocessor::HandleDirective
6.763 ms : |-(1) clang::Preprocessor::HandleIfdefDirective
6.733 ms : |-(1) clang::Preprocessor::SkipExcludedConditionalBlock
:
3.310 ms : |-(1) clang::ento::registerCStringSyntaxChecker
3.064 ms : |-(1) clang::Preprocessor::EnterSourceFile
3.041 ms : |-(1) clang::SrcMgr::ContentCache::getBuffer
3.039 ms : |-(1) clang::FileManager::getBufferForFile
3.015 ms : |-(1) _GLOBAL__N_1::RealFile::getBuffer
3.013 ms : |-(1) llvm::MemoryBuffer::getOpenFile
3.012 ms : |-(1) llvm::DICompileUnit::getEmissionKind
3.000 ms : |-(1) pread
:
1.306 ms : |-(1) clang::Preprocessor::HandleIfDirective
1.231 ms : |-(1) clang::Preprocessor::SkipExcludedConditionalBlock
:
2.121 ms : |-(1) clang::Lexer::Lex
2.121 ms : |-(1) clang::ento::registerStreamChecker

```

```
570.475 ms : (1) clang-6.0
570.475 ms : (1) main
567.307 ms : └─(1) cc1_main
14.695 ms :   └─▶(1) clang::CompilerInvocation::CreateFromArgs
:
552.319 ms :     └─(1) clang::CodeGen::CodeGenFunction::EmitOMPSimdFinal
552.235 ms :       (1) clang::CompilerInstance::ExecuteAction
14.121 ms :         └─▶(1) clang::DiagnosticConsumer::~DiagnosticConsumer
:
537.654 ms :           └─(1) clang::FrontendAction::Execute
537.651 ms :             (1) clang::CodeGenAction::ExecuteAction
537.650 ms :             (1) clang::ASTFrontendAction::ExecuteAction
537.439 ms :             (1) clang::ParseAST
14.959 ms :               └─▶(1) clang::Preprocessor::EnterMainSourceFile
:
50.500 ms :                 └─▶(1) llvm::WriteBitcodeToFile
:
2.586 ms :                   └─▶(1) llvm::BitcodeWriter::writeThinLinkBitcode
:
200.824 ms : └─(99) clang::Parser::ParseTopLevelDecl
```

```

200.715 ms : | | | (99) llvm::WriteThinLinkBitcodeToFile
68.905 ms : | | | |-(20) clang::Parser::ParseDeclaration
68.854 ms : | | | | (20) std::__introsort_loop
54.947 ms : | | | | |-(15) llvm::ValueEnumerator::OptimizeConstants
52.464 ms : | | | | | (14) clang::Parser::ExpectAndConsumeSemi
52.451 ms : | | | | | (14) clang::Preprocessor::Lex
22.955 ms : | | | | |-(4) clang::Preprocessor::CachingLex
22.943 ms : | | | | | (4) clang::Preprocessor::Lex
11.436 ms : | | | | | (3) clang::Lexer::Lex
11.434 ms : | | | | | (3) clang::ento::registerStreamChecker
11.408 ms : | | | | | (3) clang::Preprocessor::HandleDirective
6.763 ms : | | | | |-(1) clang::Preprocessor::HandleIfdefDirective
6.733 ms : | | | | | (1) clang::Preprocessor::SkipExcludedConditionalBlock
: | | | | |
3.310 ms : | | | | |-(1) clang::ento::registerCStringSyntaxChecker
3.064 ms : | | | | | (1) clang::Preprocessor::EnterSourceFile
3.041 ms : | | | | | (1) clang::SrcMgr::ContentCache::getBuffer
3.039 ms : | | | | | (1) clang::FileManager::getBufferForFile
3.015 ms : | | | | | (1) _GLOBAL__N_1::RealFile::getBuffer
3.013 ms : | | | | | (1) llvm::MemoryBuffer::getOpenFile
3.012 ms : | | | | | (1) llvm::DICompileUnit::getEmissionKind
3.000 ms : | | | | | (1) pread
: | | | | |
1.306 ms : | | | | |-(1) clang::Preprocessor::HandleIfDirective
1.231 ms : | | | | | (1) clang::Preprocessor::SkipExcludedConditionalBlock
: | | | | |
2.121 ms : | | | |-(1) clang::Lexer::Lex
2.121 ms : | | | | (1) clang::ento::registerStreamChecker

```

TOTAL TIME : FUNCTION

```
570.475 ms : (1) clang-6.0
570.475 ms : (1) main
567.307 ms : └─(1) cc1_main
14.695 ms :   └─▶(1) clang::CompilerInvocation::CreateFromArgs
:
552.319 ms :   └─(1) clang::CodeGen::CodeGenFunction::EmitOMPSimdFinal
552.235 ms :   (1) clang::CompilerInstance::ExecuteAction
14.121 ms :     └─▶(1) clang::DiagnosticConsumer::~~DiagnosticConsumer
:
537.654 ms :     └─(1) clang::FrontendAction::Execute
537.651 ms :       (1) clang::CodeGenAction::ExecuteAction
537.650 ms :       (1) clang::ASTFrontendAction::ExecuteAction
537.439 ms :       (1) clang::ParseAST
14.959 ms :         └─▶(1) clang::Preprocessor::EnterMainSourceFile
:
50.500 ms :         └─▶(1) llvm::WriteBitcodeToFile
:
2.586 ms :         └─▶(1) llvm::BitcodeWriter::writeThinLinkBitcode
:
200.824 ms :       └─(99) clang::Parser::ParseTopLevelDecl
200.715 ms :       (99) llvm::WriteThinLinkBitcodeToFile
68.905 ms :         └─▶(20) clang::Parser::ParseDeclaration
:
128.474 ms : └─(77) clang::Parser::ParseDeclarationOrFunctionDefinition
128.190 ms :   (77) clang::Parser::ParseDeclOrFunctionDefInternal
8.857 ms :     └─(3) llvm::initializeWriteBitcodePassPass
8.815 ms :     (3) llvm::LLParser::ParseStructDefinition
8.602 ms :     (3) std::__rotate_adaptive
1.167 ms :     (1) clang::Parser::ParseStructDeclaration
1.059 ms :     (1) clang::Parser::ParseSpecifierQualifierList
1.057 ms :     (1) llvm::initializeWriteBitcodePassPass
1.050 ms :     (1) llvm::LLParser::ParseStructDefinition
1.007 ms :     (1) std::__rotate_adaptive
:
97.288 ms :   └─(58) llvm::ValueEnumerator::OptimizeConstants
21.122 ms :     └─(7) clang::Parser::ExpectAndConsumeSemi
21.115 ms :     (7) clang::Preprocessor::Lex
:
3.777 ms :     └─(2) llvm::ValueEnumerator::print
3.767 ms :     (2) clang::Sema::ActOnDeclarator
3.765 ms :     (2) clang::Sema::HandleDeclarator
3.219 ms :     (2) clang::Sema::GetTypeForDeclarator
3.208 ms :     (2) GetFullTypeForDeclarator
3.159 ms :     (2) clang::Sema::BuildExpressionFromDeclTemplateArgument
1.025 ms :       └─(1) LLVMDisBuilderCreateCompileUnit
1.015 ms :       (1) LLVMCreateDisBuilder
:
2.026 ms :     └─(1) clang::Sema::BuildExpressionFromDeclTemplateArgument
```

TOTAL TIME : FUNCTION

```
570.475 ms : (1) clang-6.0
570.475 ms : (1) main
567.307 ms : | (1) cc1_main
14.695 ms : | | ▶ (1) clang::CompilerInvocation::CreateFromArgs
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537.650 ms : | | | | (1) clang::ASTFrontendAction::ExecuteAction
537.439 ms : | | | | (1) clang::ParseAST
14.959 ms : | | | | ▶ (1) clang::Preprocessor::EnterMainSourceFile
: | | | |
50.500 ms : | | | | ▶ (1) llvm::WriteBitcodeToFile
: | | | |
2.586 ms : | | | | ▶ (1) llvm::BitcodeWriter::writeThinLinkBitcode
: | | | |
200.824 ms : | | | | (99) clang::Parser::ParseTopLevelDecl
200.715 ms : | | | | (99) llvm::WriteThinLinkBitcodeToFile
68.905 ms : | | | | ▶ (20) clang::Parser::ParseDeclaration
: | | | |
128.474 ms : | | | | (77) clang::Parser::ParseDeclarationOrFunctionDefinition
128.190 ms : | | | | (77) clang::Parser::ParseDeclOrFunctionDefInternal
8.857 ms : | | | | | (3) llvm::initializeWriteBitcodePassPass
8.815 ms : | | | | | (3) llvm::LLParser::ParseStructDefinition
8.602 ms : | | | | | (3) std::__rotate_adaptive
1.167 ms : | | | | | (1) clang::Parser::ParseStructDeclaration
1.059 ms : | | | | | (1) clang::Parser::ParseSpecifierQualifierList
1.057 ms : | | | | | (1) llvm::initializeWriteBitcodePassPass
1.050 ms : | | | | | (1) llvm::LLParser::ParseStructDefinition
1.007 ms : | | | | | (1) std::__rotate_adaptive
: | | | |
97.288 ms : | | | | (58) llvm::ValueEnumerator::OptimizeConstants
21.122 ms : | | | | | (7) clang::Parser::ExpectAndConsumeSemi
21.115 ms : | | | | | (7) clang::Preprocessor::Lex
: | | | |
3.777 ms : | | | | | (2) llvm::ValueEnumerator::print
3.767 ms : | | | | | (2) clang::Sema::ActOnDeclarator
3.765 ms : | | | | | (2) clang::Sema::HandleDeclarator
3.219 ms : | | | | | (2) clang::Sema::GetTypeForDeclarator
3.208 ms : | | | | | (2) GetFullTypeForDeclarator
3.159 ms : | | | | | (2) clang::Sema::BuildExpressionFromDeclTemplateArgument
1.025 ms : | | | | | | (1) LLVMDisBuilderCreateCompileUnit
1.015 ms : | | | | | | (1) LLVMCreateDisBuilder
: | | | | |
2.026 ms : | | | | | (1) clang::Sema::BuildExpressionFromDeclTemplateArgument
```

TOTAL TIME : FUNCTION

```
570.475 ms : (1) clang-6.0
570.475 ms : (1) main
567.307 ms : | (1) cc1_main
14.695 ms : | | ▶ (1) clang::CompilerInvocation::CreateFromArgs
: | |
552.319 ms : | | | (1) clang::CodeGen::CodeGenFunction::EmitOMPSimdFinal
552.235 ms : | | | (1) clang::CompilerInstance::ExecuteAction
14.121 ms : | | | ▶ (1) clang::DiagnosticConsumer::~~DiagnosticConsumer
: | | |
537.654 ms : | | | | (1) clang::FrontendAction::Execute
537.651 ms : | | | | (1) clang::CodeGenAction::ExecuteAction
537.650 ms : | | | | (1) clang::ASTFrontendAction::ExecuteAction
537.439 ms : | | | | (1) clang::ParseAST
14.959 ms : | | | | ▶ (1) clang::Preprocessor::EnterMainSourceFile
: | | | |
50.500 ms : | | | | ▶ (1) llvm::WriteBitcodeToFile
: | | | |
2.586 ms : | | | | ▶ (1) llvm::BitcodeWriter::writeThinLinkBitcode
: | | | |
200.824 ms : | | | | | (99) clang::Parser::ParseTopLevelDecl
200.715 ms : | | | | | (99) llvm::WriteThinLinkBitcodeToFile
68.905 ms : | | | | | ▶ (20) clang::Parser::ParseDeclaration
: | | | | |
128.474 ms : | | | | | | (77) clang::Parser::ParseDeclarationOrFunctionDefinition
128.190 ms : | | | | | | (77) clang::Parser::ParseDeclOrFunctionDefInternal
8.857 ms : | | | | | | ▶ (3) llvm::initializeWriteBitcodePassPass
: | | | | |
97.288 ms : | | | | | | | (58) llvm::ValueEnumerator::OptimizeConstants
21.122 ms : | | | | | | | | (7) clang::Parser::ExpectAndConsumeSemi
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: | | | | | | | |
3.777 ms : | | | | | | | | | (2) llvm::ValueEnumerator::print
3.767 ms : | | | | | | | | | (2) clang::Sema::ActOnDeclarator
3.765 ms : | | | | | | | | | (2) clang::Sema::HandleDeclarator
3.219 ms : | | | | | | | | | (2) clang::Sema::GetTypeForDeclarator
3.208 ms : | | | | | | | | | (2) GetFullTypeForDeclarator
3.159 ms : | | | | | | | | | (2) clang::Sema::BuildExpressionFromDeclTemplateArgument
1.025 ms : | | | | | | | | | | (1) LLVMDisBuilderCreateCompileUnit
1.015 ms : | | | | | | | | | | (1) LLVMCreateDisBuilder
: | | | | | | | | | |
2.026 ms : | | | | | | | | | | | (1) clang::Sema::BuildExpressionFromDeclTemplateArgument
1.991 ms : | | | | | | | | | | | (1) LLVMDisBuilderCreateCompileUnit
1.982 ms : | | | | | | | | | | | (1) LLVMCreateDisBuilder
: | | | | | | | | | |
9.612 ms : | | | | | | | | | | | (2) std::_Rb_tree::_M_emplace_hint_unique
9.221 ms : | | | | | | | | | | | (2) clang::Parser::ParseFunctionStatementBody
9.000 ms : | | | | | | | | | | | (2) clang::Parser::ParseCompoundStatementBody
1.179 ms : | | | | | | | | | | | (1) clang::Parser::ParseStatementOrDeclaration
```

TOTAL TIME : FUNCTION

```
570.475 ms : (1) clang-6.0
570.475 ms : (1) main
567.307 ms : └─(1) cc1_main
14.695 ms :   └─▶(1) clang::CompilerInvocation::CreateFromArgs
:
552.319 ms :   └─(1) clang::CodeGen::CodeGenFunction::EmitOMPSimdFinal
552.235 ms :   (1) clang::CompilerInstance::ExecuteAction
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537.654 ms :     └─(1) clang::FrontendAction::Execute
537.651 ms :       (1) clang::CodeGenAction::ExecuteAction
537.650 ms :       (1) clang::ASTFrontendAction::ExecuteAction
537.439 ms :       (1) clang::ParseAST
14.959 ms :         └─▶(1) clang::Preprocessor::EnterMainSourceFile
:
50.500 ms :         └─▶(1) llvm::WriteBitcodeToFile
:
2.586 ms :         └─▶(1) llvm::BitcodeWriter::writeThinLinkBitcode
:
200.824 ms :         └─(99) clang::Parser::ParseTopLevelDecl
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68.905 ms :           └─▶(20) clang::Parser::ParseDeclaration
:
128.474 ms :           └─(77) clang::Parser::ParseDeclarationOrFunctionDefinition
128.190 ms :             (77) clang::Parser::ParseDeclOrFunctionDefInternal
8.857 ms :               └─▶(3) llvm::initializeWriteBitcodePassPass
:
97.288 ms :               └─(58) llvm::ValueEnumerator::OptimizeConstants
21.122 ms :               └─(7) clang::Parser::ExpectAndConsumeSemi
21.115 ms :                 (7) clang::Preprocessor::Lex
:
3.777 ms :                 └─▶(2) llvm::ValueEnumerator::print
:
9.612 ms :                 └─▶(2) std::_Rb_tree::_M_emplace_hint_unique
:
2.891 ms :                 └─▶(1) clang::Preprocessor::Lex
:
3.195 ms :                 └─▶(2) llvm::WriteThinLinkBitcodeToFile
:
15.192 ms :                 └─▶(2) clang::driver::tools::amdgpu::getAMDGPUPUTargetFeatures
:
73.558 ms :                 └─▶(1) clang::BackendConsumer::HandleTranslationUnit
:
2.178 ms : └─▶(1) llvm::llvm_shutdown
```

TOTAL TIME : FUNCTION

```
570.475 ms : (1) clang-6.0
570.475 ms : (1) main
567.307 ms : └─(1) cc1_main
14.695 ms :   └─▶(1) clang::CompilerInvocation::CreateFromArgs
:
552.319 ms :   └─(1) clang::CodeGen::CodeGenFunction::EmitOMPSimdFinal
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:
537.654 ms :     └─(1) clang::FrontendAction::Execute
537.651 ms :       (1) clang::CodeGenAction::ExecuteAction
537.650 ms :       (1) clang::ASTFrontendAction::ExecuteAction
537.439 ms :       (1) clang::ParseAST
14.959 ms :         └─▶(1) clang::Preprocessor::EnterMainSourceFile
:
50.500 ms :         └─▶(1) llvm::WriteBitcodeToFile
:
2.586 ms :         └─▶(1) llvm::BitcodeWriter::writeThinLinkBitcode
:
200.824 ms :       └─(99) clang::Parser::ParseTopLevelDecl
200.715 ms :       (99) llvm::WriteThinLinkBitcodeToFile
68.905 ms :         └─▶(20) clang::Parser::ParseDeclaration
:
128.474 ms :         └─(77) clang::Parser::ParseDeclarationOrFunctionDefinition
128.190 ms :         (77) clang::Parser::ParseDeclOrFunctionDefInternal
8.857 ms :           └─▶(3) llvm::initializeWriteBitcodePassPass
:
97.288 ms :           └─(58) llvm::ValueEnumerator::OptimizeConstants
21.122 ms :             └─(7) clang::Parser::ExpectAndConsumeSemi
21.115 ms :             (7) clang::Preprocessor::Lex
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:
9.612 ms :             └─▶(2) std::_Rb_tree::_M_emplace_hint_unique
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:
15.192 ms :           └─▶(2) clang::driver::tools::amdgpu::getAMDGPUPutTargetFeatures
:
73.558 ms :         └─▶(1) clang::BackendConsumer::HandleTranslationUnit
:
2.178 ms :       └─▶(1) llvm::llvm_shutdown
```

TOTAL TIME : FUNCTION

```
570.475 ms : (1) clang-6.0
570.475 ms : (1) main
567.307 ms : (1) cc1_main
14.695 ms : (1) clang::CompilerInvocation::CreateFromArgs
:
552.319 ms : (1) clang::CodeGen::CodeGenFunction::EmitOMPSimdFinal
552.235 ms : (1) clang::CompilerInstance::ExecuteAction
14.121 ms : (1) clang::DiagnosticConsumer::~~DiagnosticConsumer
:
537.654 ms : (1) clang::FrontendAction::Execute
537.651 ms : (1) clang::CodeGenAction::ExecuteAction
537.650 ms : (1) cl
537.439 ms : (1) cl Help: (press any key to exit)
14.959 ms : (1)
:
50.500 ms : (1) ARROW Navigation
: PgUp/Dn
: Home/End
2.586 ms : (1) Enter Select/Fold
: G Show (full) call graph
200.824 ms : (99) g Show call graph for this function
200.715 ms : (99) R Show uftrace report
68.905 ms : I Show uftrace info
: S Change session
128.474 ms : O Open editor
128.190 ms : c/e Collapse/Expand graph
8.857 ms : n/p Next/Prev sibling
: u Move up to parent
97.288 ms : l Move to the longest executed child
21.122 ms : j/k Move down/up
21.115 ms : / Search
: </>/N/P Search next/prev
3.777 ms : v Show debug message
: h/? Show this help
9.612 ms : q Quit
:
2.891 ms :
:
3.195 ms : (2) llvm::WriteThinLinkBitcodeToFile
:
15.192 ms : (2) clang::driver::tools::amdgpu::getAMDGPUPUTargetFeatures
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73.558 ms : (1) clang::BackendConsumer::HandleTranslationUnit
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: | | | | |
15.192 ms : | | | | | ▶ (2) clang::driver::tools::amdgpu::getAMDGPUPreprocessorOptions
: | | | | |
73.558 ms : | | | | | (1) clang::BackendConsumer::HandleTranslationUnit
73.262 ms : | | | | | (1) clang::EmitBackendOutput
21.243 ms : | | | | | | (1) _GLOBAL__N_1::EmitAssemblyHelper::AddEmitPasses
21.152 ms : | | | | | | (1) llvm::LLVMTargetMachine::addPassesToEmitFile
20.528 ms : | | | | | | (1) addPassesToGenerateCode
13.862 ms : | | | | | | | (1) llvm::X86TargetMachine::createPassConfig
13.858 ms : | | | | | | | (1) llvm::TargetPassConfig::TargetPassConfig
13.827 ms : | | | | | | | (1) llvm::X86TargetLowering::IsEligibleForTailCallOptimization
1.508 ms : | | | | | | | (1) llvm::initializeImplicitNullChecksPass
1.507 ms : | | | | | | | (1) pthread_once
1.505 ms : | | | | | | | (1) std::call_once::_$1::__invoke
1.504 ms : | | | | | | | (1) initializeImplicitNullChecksPassOnce
1.379 ms : | | | | | | | (1) llvm::initializeAAResultsWrapperPassPass
1.378 ms : | | | | | | | (1) pthread_once
1.377 ms : | | | | | | | (1) std::call_once::_$1::__invoke
1.376 ms : | | | | | | | (1) initializeAAResultsWrapperPassPassOnce
: | | | | | | |
2.650 ms : | | | | | | | (1) llvm::TargetPassConfig::addISelPasses
1.466 ms : | | | | | | | (1) _GLOBAL__N_1::X86PassConfig::addIRPasses
1.339 ms : | | | | | | | (1) llvm::X86FrameLowering::emitStackProbeInline
: | | | | | | |
3.911 ms : | | | | | | | (1) llvm::TargetPassConfig::addMachinePasses
: | | | | | | |
48.032 ms : | | | | | | | (1) llvm::legacy::PassManager::run
48.031 ms : | | | | | | | (1) std::vector::_M_range_insert
```

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15.192 ms : | | | | | ▶ (2) clang::driver::tools::amdgpu::getAMDGPUPreprocessorTargetFeatures
: | | | | |
73.558 ms : | | | | | (1) clang::BackendConsumer::HandleTranslationUnit
73.262 ms : | | | | | (1) clang::EmitBackendOutput
21.243 ms : | | | | | | ▶ (1) _GLOBAL__N_1::EmitAssemblyHelper::AddEmitPasses
: | | | | | |
48.032 ms : | | | | | | (1) llvm::legacy::PassManager::run
48.031 ms : | | | | | | (1) std::vector::_M_range_insert
2.038 ms : | | | | | | | (1) llvm::FPPassManager::doInitialization
1.768 ms : | | | | | | | (1) llvm::X86AsmPrinter::doInitialization
1.763 ms : | | | | | | | (1) llvm::AsmPrinter::doInitialization
1.589 ms : | | | | | | | (1) llvm::X86LinuxNaClTargetObjectFile::Initialize
1.517 ms : | | | | | | | (1) llvm::TargetLoweringObjectFile::Initialize
1.511 ms : | | | | | | | (1) llvm::MCObjectFileInfo::InitMCObjectFileInfo
1.507 ms : | | | | | | | (1) llvm::SUnit::setHeightToAtLeast
: | | | | | | |
41.484 ms : | | | | | | | (2) llvm::FPPassManager::runOnModule
41.096 ms : | | | | | | | (3) llvm::FPPassManager::runOnFunction
26.742 ms : | | | | | | | | (1) std::vector::_M_realloc_insert
26.703 ms : | | | | | | | | (1) llvm::X86TargetMachine::getSubtargetImpl
26.642 ms : | | | | | | | | (1) llvm::X86Subtarget::X86Subtarget
11.107 ms : | | | | | | | | | (1) llvm::X86InstrInfo::X86InstrInfo
1.829 ms : | | | | | | | | | (1) llvm::X86InstrFMA3Info::rm_begin
1.826 ms : | | | | | | | | | (1) llvm::X86InstrFMA3Info::initGroupsOnce
1.825 ms : | | | | | | | | | (1) pthread_once
1.820 ms : | | | | | | | | | (1) std::call_once::_$1::__invoke
1.807 ms : | | | | | | | | | (1) llvm::X86InstrFMA3Info::initGroupsOnceImpl
```

TOTAL TIME : FUNCTION

```
570.475 ms : (1) clang-6.0
570.475 ms : (1) main
567.307 ms : | (1) cc1_main
14.695 ms : | | ▶ (1) clang::CompilerInvocation::CreateFromArgs
: | |
552.319 ms : | | | (1) clang::CodeGen::CodeGenFunction::EmitOMPSimdFinal
552.235 ms : | | | (1) clang::CompilerInstance::ExecuteAction
14.121 ms : | | | | ▶ (1) clang::DiagnosticConsumer::~DiagnosticConsumer
: | | | |
537.654 ms : | | | | (1) clang::FrontendAction::Execute
537.651 ms : | | | | (1) clang::CodeGenAction::ExecuteAction
537.650 ms : | | | | (1) clang::ASTFrontendAction::ExecuteAction
537.439 ms : | | | | (1) clang::ParseAST
14.959 ms : | | | | | ▶ (1) clang::Preprocessor::EnterMainSourceFile
: | | | | |
50.500 ms : | | | | | ▶ (1) llvm::WriteBitcodeToFile
: | | | | |
2.586 ms : | | | | | ▶ (1) llvm::BitcodeWriter::writeThinLinkBitcode
: | | | | |
200.824 ms : | | | | | ▶ (99) clang::Parser::ParseTopLevelDecl
: | | | | |
15.192 ms : | | | | | ▶ (2) clang::driver::tools::amdgpu::getAMDGPUPreprocessorTargetFeatures
: | | | | |
73.558 ms : | | | | | | (1) clang::BackendConsumer::HandleTranslationUnit
73.262 ms : | | | | | | (1) clang::EmitBackendOutput
21.243 ms : | | | | | | | ▶ (1) _GLOBAL__N_1::EmitAssemblyHelper::AddEmitPasses
: | | | | | | |
48.032 ms : | | | | | | | (1) llvm::legacy::PassManager::run
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1.507 ms : | | | | | | | | (1) llvm::SUnit::setHeightToAtLeast
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41.096 ms : | | | | | | | | (3) llvm::FPPassManager::runOnFunction
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26.642 ms : | | | | | | | | | (1) llvm::X86Subtarget::X86Subtarget
11.107 ms : | | | | | | | | | | (1) llvm::X86InstrInfo::X86InstrInfo
1.829 ms : | | | | | | | | | | (1) llvm::X86InstrFMA3Info::rm_begin
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1.825 ms : | | | | | | | | | | (1) pthread_once
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537.439 ms : |      |      (1) clang::ParseAST
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:
50.500 ms : |      |      |  └─▶ (1) llvm::WriteBitcodeToFile
:
2.586 ms : |      |      |  └─▶ (1) llvm::BitcodeWriter::writeThinLinkBitcode
:
200.824 ms : |      |      |  └─▶ (99) clang::Parser::ParseTopLevelDecl
:
15.192 ms : |      |      |  └─▶ (2) clang::driver::tools::amdgpu::getAMDGPUPreprocessorTargetFeatures
:
73.558 ms : |      |      |-(1) clang::BackendConsumer::HandleTranslationUnit
73.262 ms : |      |      (1) clang::EmitBackendOutput
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48.032 ms : |      |      |-(1) llvm::legacy::PassManager::run
48.031 ms : |      |      (1) std::vector::_M_range_insert
2.038 ms : |      |      |  └─▶ (1) llvm::FPPassManager::doInitialization
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41.484 ms : |      |-(2) llvm::FPPassManager::runOnModule
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26.742 ms : |      |-(1) std::vector::_M_realloc_insert
26.703 ms : |      (1) llvm::X86TargetMachine::getSubtargetImpl
26.642 ms : |      (1) llvm::X86Subtarget::X86Subtarget
11.107 ms : |      |-(1) llvm::X86InstrInfo::X86InstrInfo
1.829 ms : |      (1) llvm::X86InstrFMA3Info::rm_begin
1.826 ms : |      (1) llvm::X86InstrFMA3Info::initGroupsOnce
1.825 ms : |      (1) pthread_once
1.820 ms : |      (1) std::call_once::_$1::__invoke
1.807 ms : |      (1) llvm::X86InstrFMA3Info::initGroupsOnceImpl
:
12.478 ms : |      |-(1) llvm::X86TargetLowering::X86TargetLowering
4.341 ms : |      (1) llvm::initializeX86FlagsCopyLoweringPassPass
:
2.644 ms : |      |-(1) llvm::X86LegalizerInfo::X86LegalizerInfo
2.324 ms : |      (1) llvm::LegalizerInfo::computeTables
```

TOTAL TIME : FUNCTION

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570.475 ms : (1) clang-6.0
570.475 ms : (1) main
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537.651 ms : |      |      (1) clang::CodeGenAction::ExecuteAction
537.650 ms : |      |      (1) clang::ASTFrontendAction::ExecuteAction
537.439 ms : |      |      (1) clang::ParseAST
14.959 ms : |      |      |  └─▶ (1) clang::Preprocessor::EnterMainSourceFile
:
50.500 ms : |      |      |  └─▶ (1) llvm::WriteBitcodeToFile
:
2.586 ms : |      |      |  └─▶ (1) llvm::BitcodeWriter::writeThinLinkBitcode
:
200.824 ms : |      |      |  └─▶ (99) clang::Parser::ParseTopLevelDecl
:
15.192 ms : |      |      |  └─▶ (2) clang::driver::tools::amdgpu::getAMDGPUPreprocessorTargetFeatures
:
73.558 ms : |      |      |-(1) clang::BackendConsumer::HandleTranslationUnit
73.262 ms : |      |      (1) clang::EmitBackendOutput
21.243 ms : |      |      |  └─▶ (1) _GLOBAL__N_1::EmitAssemblyHelper::AddEmitPasses
:
48.032 ms : |      |      |-(1) llvm::legacy::PassManager::run
48.031 ms : |      |      (1) std::vector::_M_range_insert
2.038 ms : |      |      |  └─▶ (1) llvm::FPPassManager::doInitialization
:
41.484 ms : |      |      |-(2) llvm::FPPassManager::runOnModule
41.096 ms : |      |      (3) llvm::FPPassManager::runOnFunction
26.742 ms : |      |      |-(1) std::vector::_M_realloc_insert
26.703 ms : |      |      (1) llvm::X86TargetMachine::getSubtargetImpl
26.642 ms : |      |      (1) llvm::X86Subtarget::X86Subtarget
11.107 ms : |      |      |-(1) llvm::X86InstrInfo::X86InstrInfo
1.829 ms : |      |      (1) llvm::X86InstrFMA3Info::rm_begin
1.826 ms : |      |      (1) llvm::X86InstrFMA3Info::initGroupsOnce
1.825 ms : |      |      (1) pthread_once
1.820 ms : |      |      (1) std::call_once::_$1::__invoke
1.807 ms : |      |      (1) llvm::X86InstrFMA3Info::initGroupsOnceImpl
:
12.478 ms : |      |      |-(1) llvm::X86TargetLowering::X86TargetLowering
4.341 ms : |      |      (1) llvm::initializeX86FlagsCopyLoweringPassPass
:
2.644 ms : |      |      |-(1) llvm::X86LegalizerInfo::X86LegalizerInfo
2.324 ms : |      |      (1) llvm::LegalizerInfo::computeTables
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TOTAL TIME : FUNCTION

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570.475 ms : (1) clang-6.0
570.475 ms : (1) main
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552.235 ms : |      (1) clang::CompilerInstance::ExecuteAction
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537.654 ms : |      |      |-(1) clang::FrontendAction::Execute
537.651 ms : |      |      (1) clang::CodeGenAction::ExecuteAction
537.650 ms : |      |      (1) clang::ASTFrontendAction::ExecuteAction
537.439 ms : |      |      (1) clang::ParseAST
14.959 ms : |      |      |  └▶(1) clang::Preprocessor::EnterMainSourceFile
:
50.500 ms : |      |      |  └▶(1) llvm::WriteBitcodeToFile
:
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:
200.824 ms : |      |      |  └▶(99) clang::Parser::ParseTopLevelDecl
:
15.192 ms : |      |      |  └▶(2) clang::driver::tools::amdgpu::getAMDGPUPreprocessorTargetFeatures
:
73.558 ms : |      |      |-(1) clang::BackendConsumer::HandleTranslationUnit
73.262 ms : |      |      (1) clang::EmitBackendOutput
21.243 ms : |      |      |  └▶(1) _GLOBAL__N_1::EmitAssemblyHelper::AddEmitPasses
:
48.032 ms : |      |      |-(1) llvm::legacy::PassManager::run
48.031 ms : |      |      (1) std::vector::_M_range_insert
2.038 ms : |      |      |  └▶(1) llvm::FPPassManager::doInitialization
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41.484 ms : |      |      |-(2) llvm::FPPassManager::runOnModule
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26.642 ms : |      |      (1) llvm::X86Subtarget::X86Subtarget
11.107 ms : |      |      |-(1) llvm::X86InstrInfo::X86InstrInfo
1.829 ms : |      |      (1) llvm::X86InstrFMA3Info::rm_begin
1.826 ms : |      |      (1) llvm::X86InstrFMA3Info::initGroupsOnce
1.825 ms : |      |      (1) pthread_once
1.820 ms : |      |      (1) std::call_once::_$1::__invoke
1.807 ms : |      |      (1) llvm::X86InstrFMA3Info::initGroupsOnceImpl
:
12.478 ms : |      |      |-(1) llvm::X86TargetLowering::X86TargetLowering
4.341 ms : |      |      (1) llvm::initializeX86FlagsCopyLoweringPassPass
:
2.644 ms : |      |      |-(1) llvm::X86LegalizerInfo::X86LegalizerInfo
2.324 ms : |      |      (1) llvm::LegalizerInfo::computeTables
```

TOTAL TIME : FUNCTION

```
570.475 ms : (1) clang-6.0
570.475 ms : (1) main
567.307 ms : | (1) cc1_main
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552.319 ms : | | (1) clang::CodeGen::CodeGenFunction::EmitOMPSimdFinal
552.235 ms : | | (1) clang::CompilerInstance::ExecuteAction
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537.651 ms : | | | (1) clang::CodeGenAction::ExecuteAction
537.650 ms : | | | (1) clang::ASTFrontendAction::ExecuteAction
537.439 ms : | | | (1) clang::ParseAST
14.959 ms : | | | | ▶ (1) clang::Preprocessor::EnterMainSourceFile
: | | | |
50.500 ms : | | | | ▶ (1) llvm::WriteBitcodeToFile
: | | | |
2.586 ms : | | | | ▶ (1) llvm::BitcodeWriter::writeThinLinkBitcode
: | | | |
200.824 ms : | | | | ▶ (99) clang::Parser::ParseTopLevelDecl
: | | | |
15.192 ms : | | | | ▶ (2) clang::driver::tools::amdgpu::getAMDGPUPreprocessorFeatures
: | | | |
73.558 ms : | | | | (1) clang::BackendConsumer::HandleTranslationUnit
73.262 ms : | | | | (1) clang::EmitBackendOutput
21.243 ms : | | | | | ▶ (1) _GLOBAL__N_1::EmitAssemblyHelper::AddEmitPasses
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48.032 ms : | | | | | (1) llvm::legacy::PassManager::run
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41.484 ms : | | | | | | (2) llvm::FPPassManager::runOnModule
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26.742 ms : | | | | | | | (1) std::vector::M_realloc_insert
26.703 ms : | | | | | | | (1) llvm::X86TargetMachine::getSubtargetImpl
26.642 ms : | | | | | | | (1) llvm::X86Subtarget::X86Subtarget
11.107 ms : | | | | | | | | (1) llvm::X86InstrInfo::X86InstrInfo
1.829 ms : | | | | | | | | (1) llvm::X86InstrFMA3Info::rm_begin
1.826 ms : | | | | | | | | (1) llvm::X86InstrFMA3Info::initGroupsOnce
1.825 ms : | | | | | | | | (1) pthread_once
1.820 ms : | | | | | | | | (1) std::call_once::_$1::_invoke
1.807 ms : | | | | | | | | (1) llvm::X86InstrFMA3Info::initGroupsOnceImpl
: | | | | | | | |
12.478 ms : | | | | | | | | (1) llvm::X86TargetLowering::X86TargetLowering
4.341 ms : | | | | | | | | (1) llvm::initializeX86FlagsCopyLoweringPassPass
: | | | | | | | |
2.644 ms : | | | | | | | | (1) llvm::X86LegalizerInfo::X86LegalizerInfo
2.324 ms : | | | | | | | | (1) llvm::LegalizerInfo::computeTables
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TOTAL TIME : FUNCTION

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570.475 ms : (1) clang-6.0
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537.439 ms : |      |      (1) clang::ParseAST
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570.475 ms : (1) clang-6.0
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11.107 ms :                         └─▶(1) llvm::X86InstrInfo::X86InstrInfo
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4.341 ms :                           (1) llvm::initializeX86FlagsCopyLoweringPassPass
:
2.644 ms :                           └─▶(1) llvm::X86LegalizerInfo::X86LegalizerInfo
:
8.303 ms :                           └─▶(4) llvm::MachineFunctionPass::runOnFunction
:
3.969 ms :                           └─▶(1) llvm::FPPassManager::doFinalization
:
2.178 ms : └─▶(1) llvm::llvm_shutdown
```

TOTAL TIME : FUNCTION

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570.475 ms : (1) clang-6.0
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14.959 ms :         └─▶(1) clang::Preprocessor::EnterMainSourceFile
:
50.500 ms :         └─▶(1) llvm::WriteBitcodeToFile
:
2.586 ms :         └─▶(1) llvm::BitcodeWriter::writeThinLinkBitcode
:
200.824 ms :         └─▶(99) clang::Parser::ParseTopLevelDecl
:
15.192 ms :         └─▶(2) clang::driver::tools::amdgpu::getAMDGPUPreprocessorTargetFeatures
:
73.558 ms :         └─(1) clang::BackendConsumer::HandleTranslationUnit
73.262 ms :           (1) clang::EmitBackendOutput
21.243 ms :             └─▶(1) _GLOBAL__N_1::EmitAssemblyHelper::AddEmitPasses
:
48.032 ms :             └─(1) llvm::legacy::PassManager::run
48.031 ms :               (1) std::vector::_M_range_insert
2.038 ms :                 └─▶(1) llvm::FPPassManager::doInitialization
:
41.484 ms :                 └─(2) llvm::FPPassManager::runOnModule
41.096 ms :                   (3) llvm::FPPassManager::runOnFunction
26.742 ms :                     └─(1) std::vector::_M_realloc_insert
26.703 ms :                       (1) llvm::X86TargetMachine::getSubtargetImpl
26.642 ms :                       (1) llvm::X86Subtarget::X86Subtarget
11.107 ms :                         └─▶(1) llvm::X86InstrInfo::X86InstrInfo
:
12.478 ms :                         └─(1) llvm::X86TargetLowering::X86TargetLowering
4.341 ms :                           (1) llvm::initializeX86FlagsCopyLoweringPassPass
:
2.644 ms :                           └─▶(1) llvm::X86LegalizerInfo::X86LegalizerInfo
:
8.303 ms :                           └─▶(4) llvm::MachineFunctionPass::runOnFunction
:
3.969 ms :                           └─▶(1) llvm::FPPassManager::doFinalization
:
2.178 ms : └─▶(1) llvm::llvm_shutdown
```

V8 JavaScript Engine

TOTAL TIME : FUNCTION	
865.436 ms	(1) d8
834.139 ms	└─(138) sched-in
	└─
31.297 ms	└─(1) v8::internal::GCExtension::GC
31.290 ms	(1) v8::Isolate::RequestGarbageCollectionForTesting
31.287 ms	(1) v8::internal::Heap::CollectAllGarbage
31.285 ms	(1) v8::internal::Heap::CollectGarbage
40.573 us	└─(1) v8::internal::GCTracer::Start
	└─
16.968 us	└─(1) v8::internal::Heap::GarbageCollectionPrologue
	└─
30.659 ms	└─(1) v8::internal::Heap::PerformGarbageCollection
150.236 us	└─▶(1) v8::internal::SemiSpace::Commit
	└─
679.669 us	└─▶(1) v8::internal::StoreBuffer::MoveAllEntriesToRememberedSet
	└─
29.626 ms	└─(1) v8::internal::Heap::MarkCompact
30.383 us	└─(1) v8::internal::PauseAllocationObserversScope::PauseAllocationObserversScope
	└─
35.649 us	└─▶(1) v8::internal::PagedSpace::SetReadAndWritable
	└─
67.791 us	└─▶(1) v8::internal::MarkCompactCollector::Prepare
	└─
30.692 us	└─(1) v8::internal::Heap::MarkCompactPrologue
	└─
28.685 ms	└─(1) v8::internal::MarkCompactCollector::CollectGarbage
22.614 ms	└─▶(1) v8::internal::MarkCompactCollector::MarkLiveObjects
	└─
135.463 us	└─▶(1) v8::internal::MarkCompactCollector::ClearNonLiveReferences
	└─
0.508 us	└─(1) v8::internal::MarkCompactCollector::VerifyMarking
	└─
0.249 us	└─(1) v8::internal::MarkCompactCollector::RecordObjectStats
	└─
76.772 us	└─▶(1) v8::internal::MarkCompactCollector::StartSweepSpaces
	└─
5.673 ms	└─▶(1) v8::internal::MarkCompactCollector::Evacuate
	└─
178.967 us	└─▶(1) v8::internal::MarkCompactCollector::Finish

```

28.685 ms : (1) v8::internal::MarkCompactCollector::CollectGarbage
22.614 ms : └─(1) v8::internal::MarkCompactCollector::MarkLiveObjects
30.403 us : └─(10) v8::internal::GCTracer::Scope::Scope
24.390 us : └─(10) v8::internal::Heap::MonotonicallyIncreasingTimeInMs
1.143 us : └─(10) v8::internal::V8::GetCurrentPlatform
:
12.364 us : └─(10) v8::platform::DefaultPlatform::MonotonicallyIncreasingTime
7.132 us : └─(10) v8::base::TimeTicks::Now
1.566 us : └─(10) clock_gettime
:
16.998 us : └─(10) v8::internal::tracing::TraceEventHelper::GetTracingController
1.246 us : └─(10) v8::internal::V8::GetCurrentPlatform
:
2.104 us : └─(10) v8::internal::wasm::WasmInterpreter::Thread::NumInterpretedCalls
:
5.720 us : └─(10) v8::platform::tracing::TracingController::GetCategoryGroupEnabled
:
4.450 us : └─(1) v8::internal::StackGuard::PushInterruptsScope
1.444 us : └─(1) v8::base::Mutex::Lock
0.370 us : └─(1) pthread_mutex_lock
:
0.220 us : └─(1) v8::internal::Heap::SetStackLimits
:
0.950 us : └─(1) v8::base::Mutex::Unlock
0.274 us : └─(1) pthread_mutex_unlock
:
44.078 us : └─(10) v8::internal::GCTracer::Scope::~~Scope
36.678 us : └─(10) v8::internal::Heap::MonotonicallyIncreasingTimeInMs
1.837 us : └─(10) v8::internal::V8::GetCurrentPlatform
:
17.960 us : └─(10) v8::platform::DefaultPlatform::MonotonicallyIncreasingTime
9.936 us : └─(10) v8::base::TimeTicks::Now
1.939 us : └─(10) clock_gettime
:
0.234 us : └─(1) v8::internal::LocalEmbedderHeapTracer::EnterFinalPause

```

```
28.685 ms : (1) v8::internal::MarkCompactCollector::CollectGarbage
22.614 ms : |▶ (1) v8::internal::MarkCompactCollector::MarkLiveObjects
: |
135.463 us : |▶ (1) v8::internal::MarkCompactCollector::ClearNonLiveReferences
: |
0.508 us : |─(1) v8::internal::MarkCompactCollector::VerifyMarking
: |
0.249 us : |─(1) v8::internal::MarkCompactCollector::RecordObjectStats
: |
76.772 us : |▶ (1) v8::internal::MarkCompactCollector::StartSweepSpaces
: |
5.673 ms : |▶ (1) v8::internal::MarkCompactCollector::Evacuate
: |
178.967 us : |▶ (1) v8::internal::MarkCompactCollector::Finish
```

```

28.685 ms : (1) v8::internal::MarkCompactCollector::CollectGarbage
22.614 ms : |▶ (1) v8::internal::MarkCompactCollector::MarkLiveObjects
: |
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: |
0.249 us : |—(1) v8::internal::MarkCompactCollector::RecordObjectStats
: |
76.772 us : |▶ (1) v8::internal::MarkCompactCollector::StartSweepSpaces
: |
5.673 ms : |▶ (1) v8::internal::MarkCompactCollector::Evacuate
: |
178.967 us : |▶ (1) v8::internal::MarkCompactCollector::Finish

```

Help: (press any key to exit)

ARROW	Navigation
PgUp/Dn	
Home/End	
Enter	Select/Fold
G	Show (full) call graph
g	Show call graph for this function
R	Show uftrace report
I	Show uftrace info
S	Change session
O	Open editor
c /e	Collapse /Expand graph
n/p	Next/Prev sibling
u	Move up to parent
l	Move to the longest executed child
j/k	Move down/up
/	Search
</>/N/P	Search next/prev
v	Show debug message
h/?	Show this help
q	Quit

'c': Collapse graph

CollectGarbage

```
28.685 ms : (1) v8::internal::MarkCompactCollector::CollectGarbage
22.614 ms :   ► (1) v8::internal::MarkCompactCollector::MarkLiveObjects
:
135.463 us :   ► (1) v8::internal::MarkCompactCollector::ClearNonLiveReferences
:
0.508 us :   └ (1) v8::internal::MarkCompactCollector::VerifyMarking
:
0.249 us :   └ (1) v8::internal::MarkCompactCollector::RecordObjectStats
:
76.772 us :   ► (1) v8::internal::MarkCompactCollector::StartSweepSpaces
:
5.673 ms :   ► (1) v8::internal::MarkCompactCollector::Evacuate
:
178.967 us :   ► (1) v8::internal::MarkCompactCollector::Finish
```

```
$ uftrace record --auto-args -E linux:schedule ./d8 --expose-gc -e 'gc()'
```

```
$ uftrace tui -F v8::internal::GCExtension::GC -t 10us \
-T v8::internal::MarkCompactCollector::CollectGarbage@time=0s
```

CollectGarbage

```
void MarkCompactCollector::CollectGarbage() {
    // Make sure that Prepare() has been called. The individual steps below will
    // update the state as they proceed.
    DCHECK(state_ == PREPARE_GC);

#ifdef ENABLE_MINOR_MC
    heap()->minor_mark_compact_collector()->CleanupSweepToIteratePages();
#endif // ENABLE_MINOR_MC

    MarkLiveObjects();
    ClearNonLiveReferences();
    VerifyMarking();

    RecordObjectStats();

    StartSweepSpaces();

    Evacuate();

    Finish();
}
```

CollectGarbage

```
void MarkCompactCollector::CollectGarbage() {
    // Make sure that Prepare() has been called. The individual steps below will
    // update the state as they proceed.
    DCHECK(state_ == PREPARE_GC);

#ifdef ENABLE_MINOR_MC
    heap()->minor_mark_compact_collector()->CleanupSweepToIteratePages();
#endif // ENABLE_MINOR_MC

    MarkLiveObjects();
    ClearNonLiveReferences();
    VerifyMarking();

    RecordObjectStats();

    StartSweepSpaces();
    Evacuate();
    Finish();
}
```

28.685 ms	:	(1) v8::internal::MarkCompactCollector::CollectGarbage
22.614 ms	:	▶ (1) v8::internal::MarkCompactCollector::MarkLiveObjects
:	:	:
135.463 us	:	▶ (1) v8::internal::MarkCompactCollector::ClearNonLiveReferences
:	:	:
0.508 us	:	— (1) v8::internal::MarkCompactCollector::VerifyMarking
:	:	:
0.249 us	:	— (1) v8::internal::MarkCompactCollector::RecordObjectStats
:	:	:
76.772 us	:	▶ (1) v8::internal::MarkCompactCollector::StartSweepSpaces
:	:	:
5.673 ms	:	▶ (1) v8::internal::MarkCompactCollector::Evacuate
:	:	:
178.967 us	:	▶ (1) v8::internal::MarkCompactCollector::Finish

CollectGarbage

```
void MarkCompactCollector::CollectGarbage() {  
    // Make sure that Prepare() has been called. The individual steps below will  
    // update the state as they proceed.  
    DCHECK(state_ == PREPARE_GC);
```

실행되지 않는 코드

```
#ifdef ENABLE_MINOR_MC  
    heap()->minor_mark_compact_collector()->CleanupSweepToIteratePages();  
#endif // ENABLE_MINOR_MC
```

```
    MarkLiveObjects();  
    ClearNonLiveReferences();  
    VerifyMarking();
```

```
    RecordObjectStats();
```

```
    StartSweepSpaces();  
    Evacuate();  
    Finish();  
}
```

28.685 ms	:	(1) v8::internal::MarkCompactCollector::CollectGarbage
22.614 ms	:	▶ (1) v8::internal::MarkCompactCollector::MarkLiveObjects
:	:	:
135.463 us	:	▶ (1) v8::internal::MarkCompactCollector::ClearNonLiveReferences
:	:	:
0.508 us	:	— (1) v8::internal::MarkCompactCollector::VerifyMarking
:	:	:
0.249 us	:	— (1) v8::internal::MarkCompactCollector::RecordObjectStats
:	:	:
76.772 us	:	▶ (1) v8::internal::MarkCompactCollector::StartSweepSpaces
:	:	:
5.673 ms	:	▶ (1) v8::internal::MarkCompactCollector::Evacuate
:	:	:
178.967 us	:	▶ (1) v8::internal::MarkCompactCollector::Finish

(Python) Scripting Support

```
$ gcc -pg test.c
```

```
$ uftrace -S count.py a.out
```

3

```
# FUNCTION
```

```
main() {  
    foo() {  
        bar() {  
            } /* bar */  
        } /* foo */  
    } /* main */
```

```
$ cat count.py
```

```
count = 0
```

```
def uftrace_begin():  
    pass
```

```
def uftrace_entry(args):  
    global count  
    count += 1
```

```
def uftrace_exit(args):  
    pass
```

```
def uftrace_end():  
    print(count)
```

Context Info to Script

```
/* context information passed to script */
script_context = {
    int      tid;
    int      depth;
    long     timestamp;
    long     duration;      # exit only
    long     address;
    string   name;
    list     args;          # entry only (if available)
    value    retval;        # exit only (if available)
};
```

감사합니다

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

<https://gitter.im/uftrace/ko>