bpftrace - A strong linux trace tool

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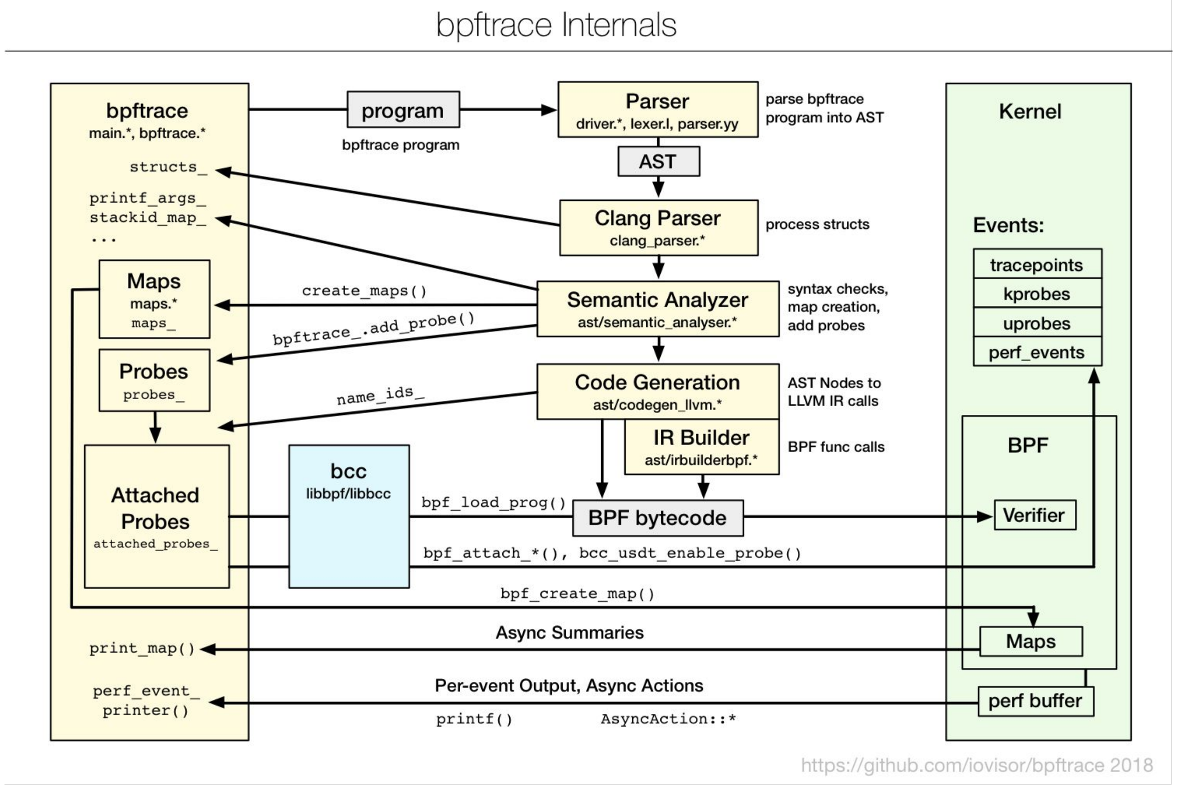
Agenda

- Background
- Bpftrace synopsis
- Demos - trace daily work

Bpftrace background

- Bpftrace (DTrace 2.0) for Linux 2018
  - Bpftace announce at Oct, 2018. Use bpftrace feature since 4.9 kernel.
  - Language: similar to dtrace, awk, c(systemtap).
  - Using:
    - Trace
    - Performance
    - Troubleshooting

Bpftrace synopsis - internals



Bpftrace synopsis - probes

kprobe	Kernel function start
kretprobe	Kernel function return
uprobe	User-level function start
uretprobe	User-level function return
tracepoint	Kernel static tracepoints
usdt	User-level static tracepoint
profile	Timed sampling
interval	Timed output
software	Kernel software events
hardware	Processor-level events

Bpftrace synopsis - built-in variables and functions

Variable	Description
pid	Process ID
comm	Process or command name
nsecs	Current time in nanoseconds
kstack	Kernel stack trace
ustack	User-level stack trace
arg0...argN	Function arguments
args	Tracepoint arguments
retval	Function return value
name	Full probe name

Function	Description
printf("...")	Print formatted string
time("...")	Print formatted time
system("...")	Run shell command
@ = count()	Count events
@ = hist(x)	Power-of-2 histogram for x
@ = lhist(x, min, max, step)	Linear histogram for x

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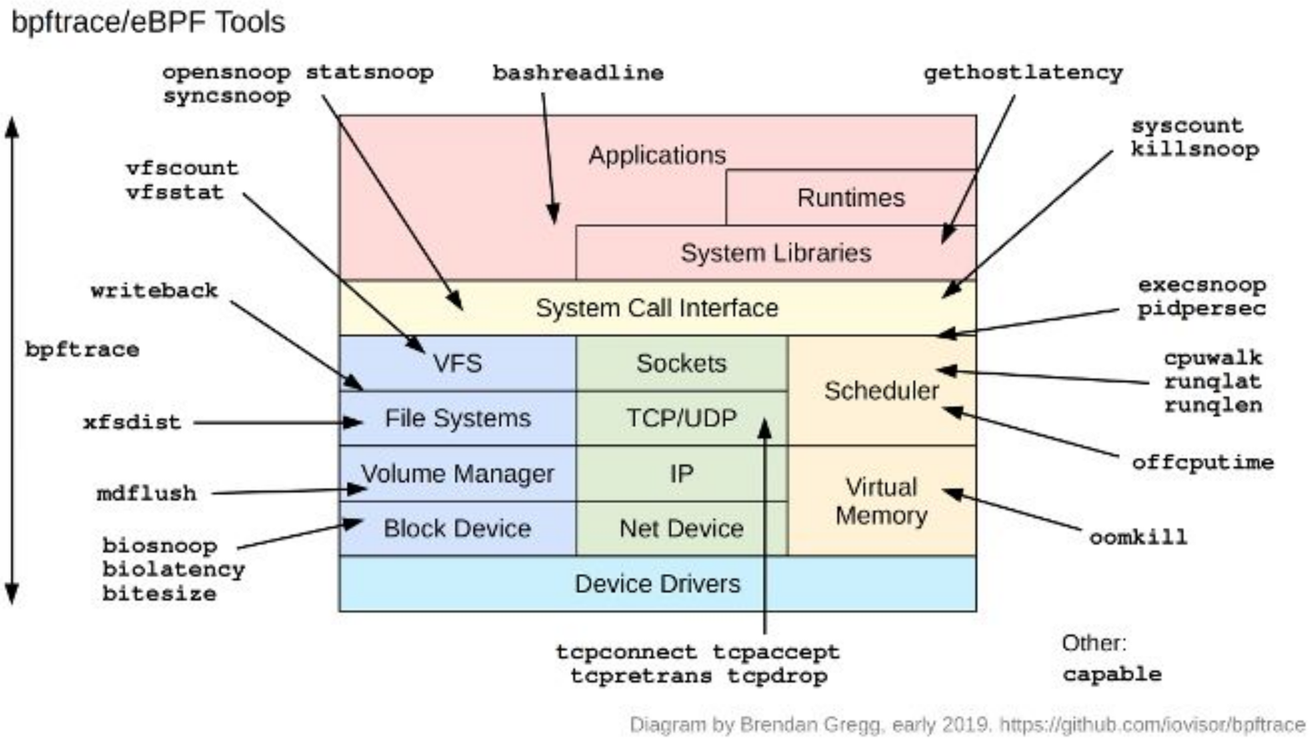
Bpftrace synopsis - one line command

```
# bpftrace -e 'BEGIN { printf("hello world\n"); }'

# bpftrace -e 'kprobe:do_nanosleep { printf("%s sleep by %d\n", comm, tid); }'

# bpftrace -e 'uprobe:/lib64/libc.so.6:fopen { printf("fopen: %s\n", str(arg0)); }'
# bpftrace -e 'uretprobe:/bin/bash:readline { printf("readline: \"%s\"\n", str(retval)); }'

# bpftrace -e 'tracepoint:sched:sched_switch { @[kstack] = count() }'

# bpftrace -e 'kprobe:tcp_sendmsg { @size = hist(arg2); } interval:s:10 { exit(); }'

# bpftrace -e 'software:page-faults:100 { @[comm] = count(); }'
```

More: https://github.com/iovisor/bpftrace/blob/master/docs/

Bpftrace synopsis - provided tools



Basic demos - k/uprobe; k/uretprobe

```
# bpftrace -e 'kprobe:_do_fork { @[comm] = count(); }'
```

```
Attaching 1 probe...
@[ThreadPoolForeg]: 1
@[kthreadd]: 1
@[chrome]: 1
```

```
# bpftrace -e 'uretprobe:/bin/bash:readline { printf("readline: \"%s\"\n", str(retval)); }'
```

```
Attaching 1 probe...
readline: "cd Git/linux/"
readline: "cat /proc/cmdline"
...
```

Basic demos - count syscall

```
# bpftrace -e 'tracepoint:raw_syscalls:sys_enter { @[comm] = count() }'
```

```
Attaching 1 probe...
^C
@[gssproxy]: 1
@[sssd]: 1
@[sedispatch]: 1
@[CacheThread_Blo]: 3
@[Chrome_SyncThre]: 4
@[sudo]: 5
@[Chrome_HistoryT]: 9
```

Basic demos - count syscall

```
# cat syscount.bt

#!/usr/bin/env bpftrace
BEGIN
{
        printf("Counting syscalls... Hit Ctrl-C to end.\n");
}
tracepoint:raw_syscalls:sys_enter
{
        @syscall[args->id] = count();
        @process[comm] = count();
}
END
{
        printf("\nTop 10 syscalls IDs:\n");
        print(@syscall, 10);
        clear(@syscall);
        printf("\nTop 10 processes:\n");
        print(@process, 10);
        clear(@process);
}
```

```
# bpftrace syscount.bt

Attaching 3 probes...
Counting syscalls... Hit Ctrl-C to end.
^C

Top 10 syscalls IDs:
@syscall[38]: 180
@syscall[20]: 289
...
@syscall[232]: 524
@syscall[7]: 648
@syscall[0]: 738
@syscall[16]: 1095
@syscall[47]: 1691

Top 10 processes:
@process[clock-applet]: 115
@process[gdbus]: 116
@process[Timer]: 125
...
@process[Web Content]: 491
@process[chrome]: 552
@process[Xorg]: 1863
@process[mate-multiload-]: 2019
```

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Basic demos - kernel stack

# bpftrace -e 'k:tcp_sendmsg { @[kstack] = count(); }'

```
Attaching 1 probes...
@[
    tcp_sendmsg+1
    sock_sendmsg+65
    sock_write_iter+143
    new_sync_write+301
    vfs_write+182
    ksys_write+95
    do_syscall_64+95
    entry_SYSCALL_64_after_hwframe+68
]: 18

@[
    tcp_sendmsg+1
    sock_sendmsg+65
    __sys_sendto+238
    __x64_sys_sendto+37
    do_syscall_64+95
    entry_SYSCALL_64_after_hwframe+68
]: 59
```

Basic demos - tcp_sendmsg performance

```
# bpftrace -e 'k:tcp_sendmsg { @size = hist(arg2); } interval:s:10 { exit(); }'
```

```
Attaching 2 probes...
@size:
[2, 4)         4 |@@@@@@@@@@@@@@@@@@@@@@@@@@@@@                       |
[4, 8)         0 |                                                    |
[8, 16)        2 |@@@@@@@@@@@@@@                                      |
[16, 32)       2 |@@@@@@@@@@@@@@                                      |
[32, 64)       4 |@@@@@@@@@@@@@@@@@@@@@@@@@@@@@                       |
[64, 128)      3 |@@@@@@@@@@@@@@@@@@@@@@                              |
[128, 256)     5 |@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@               |
[256, 512)     4 |@@@@@@@@@@@@@@@@@@@@@@@@@@@@@                       |
[512, 1K)      7 |@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@|
[1K, 2K)       1 |@@@@@@@                                             |
[2K, 4K)       5 |@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@               |
```

The Largest is 2k to 4k range, this is using a kprobe(‘k’) on tcp_sendmsg(), and saving a histogram of arg2 (size) to a BPF map named "@size" (the name is unimportant). An interval event fires after 10 seconds and exits, at which point all BPF maps are printed. (Play the video in the background)
> int tcp_sendmsg(struct sock *sk, struct msghdr *msg, size_t size)

Basic demos - process debugging

```
# bpftrace -e 'kprobe:vfs_read /pid == 3412/ { @start[tid] = nsecs; } kretprobe:vfs_read /@start[tid]/ {
@ns = hist(nsecs - @start[tid]); delete(@start[tid]); } interval:s:30 { exit(); }'
```

```
Attaching 3 probes...
@ns:
[1K, 2K)               4 |@@                                                  |
[2K, 4K)              23 |@@@@@@@@@@@                                         |
[4K, 8K)              48 |@@@@@@@@@@@@@@@@@@@@@@@@                            |
[8K, 16K)            104 |@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@|
[16K, 32K)             3 |@                                                   |
[32K, 64K)             1 |                                                    |
```

Process 3412 are firefox, bpftrace one-liners can easy to get the threads latency for vfs_read. Once you have performance issue, bpftrace can help. It can be of more use in helping to eliminate latency outliers.

Basic demos - debug disk open/read

```
# bpftrace -e 'kprobe:vfs_read /pid == 19063/ { @start[tid] = nsecs; } kretprobe:vfs_read /@start[tid]/
{ @ns = hist(nsecs - @start[tid]); delete(@start[tid]); } interval:s:30 { exit(); }'
```

```
Attaching 3 probes...    [pid 19063 are command “dd if=/dev/random of=/tmp/t.img”]
@ns:
[2K, 4K)               2 |                                                    |
[4K, 8K)              18 |@                                                   |
[8K, 16K)             20 |@                                                   |
[16K, 32K)           543 |@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@                    |
[32K, 64K)           349 |@@@@@@@@@@@@@@@@@@@@                                |
[64K, 128K)          872 |@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@|
[128K, 256K)         195 |@@@@@@@@@@@                                         |
[256K, 512K)          83 |@@@@                                                |
[512K, 1M)            10 |                                                    |
[1M, 2M)               2 |                                                    |
[2M, 4M)               2 |                                                    |
[64M, 128M)            2 |                                                    |
[128M, 256M)           5 |                                                    |
[256M, 512M)          91 |@@@@@                                               |
@start[19063]: 34841858126989
```

Basic demos - include source file like c language

Use “.bt” file: (use kernel function)

```
# include <linux/path.h>
# include <linux/dcache.h>
kprobe:vfs_open
{
   printf("open path: %s\n", str(((path *)arg0)->dentry->d_name.name));
}
```

```
# bpftrace -v path.bt

Attaching kprobe:vfs_open
Running...
open path: interrupts
open path: stat
open path: smp_affinity
```

C struct navigation (similar with systemtap)

Reference

https://lwn.net/Articles/767956/
https://github.com/iovisor/bpftrace
https://github.com/iovisor/bpftrace/tree/master/tools
https://tracingsummit.org/wiki/TracingSummit2018#Schedule

Thanks

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