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Valgrind

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Valgrind - Introduction

What is Valgrind?

- A collection of tools for memory missmanagment detection and profiling on linux and mac

What can Valgrind do for you?

- Detect memory leaks
- Detect reads/writes inappropriate areas of memory
- Profile function execution
- Profile cache hit/miss
- And many more

Valgrind – Memory leak detection

Memcheck:

valgrind --tool=memcheck --leak-check=yes program

- Program runs several times slower
- Code need to be compiled in debug
- Output is shown on the terminal

```
 3 void foo()
 4 {
 5     float* f = new float[10];
 6 }
 7 int main()
 8 {
 9     foo();
10     return 0;
11 }
```

```
==1632== HEAP SUMMARY:
==1632==     in use at exit: 40 bytes in 1 blocks
==1632==   total heap usage: 1 allocs, 0 frees, 40 bytes allocated
==1632==
==1632== 40 bytes in 1 blocks are definitely lost in loss record 1 of 1
==1632==    at 0x4C2B307: operator new[](unsigned long) (in /usr/lib/valg
==1632==    by 0x4006FD: foo() (main.cpp:5)
==1632==    by 0x40070C: main (main.cpp:9)
==1632==
==1632== LEAK SUMMARY:
==1632==    definitely lost: 40 bytes in 1 blocks
==1632==    indirectly lost: 0 bytes in 0 blocks
==1632==      possibly lost: 0 bytes in 0 blocks
==1632==    still reachable: 0 bytes in 0 blocks
==1632==         suppressed: 0 bytes in 0 blocks
```

Valgrind – Leak types

Definitely lost:

- Memory is lost. Error need to be fixed !

Indirectly lost:

- Memory is indirectily lost through a pointer. When the root of a tree is defiinetly lost, all childs are inderectly lost.

Possibly lost:

- Pointer to the buffer start is lost, but another pointer references part of the buffer

Still reachable:

- Memory is still reachable that could have been deleted

Valgrind – Memory leak detection

What memcheck can also detect:

1. Usage of uninitialized variables
2. Missmatch of new/[ ]/malloc and delete/[ ]/free
3. Accessviolations in heap memory

What memcheck can't find:

4. Out of bound checks in arrays allocated on the stack

```
 6 // 2. mismatch new / free
 7 float* f = new float[10];
 8 free(f);
 9
10 // 3. access violations
11 char* c = new char[10];
12 c[10] = 'a';
13
14 // 4. out of bound check
15 int i[10];
16 i[10]=2; // won't be detected
17
```

Valgrind – Profiling with callgrind

Callgrind:

- The callgrind tool records the callhistory and instructions issued per function
- Results are stored in a file
- Caches can be simulated
- Available for different Architectures

Usage:

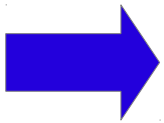
valgrind --tool=callgrind --dump-instr=yes –simulate-cache=yes program

Hint: (compile program in release with debuginfo)

Valgrind – Profiling with callgrind

Problems:

- Program runs 4 – 20 times slower
- Everything is simulated and captured, also parts of the program that are not interesting



Only the code of interest need to be profiled

Valgrind – How to profile

Macros for profiling parts of the code are provided by ***callgrind.h***

Disable simulation and capture via commandline arguments:

- --instr-atstart=<yes|no> [default: yes] (disable simulation)
- --collect-atstart=<yes|no> [default: yes] (disable capture)

Macros:

- **Start simulation:**

  CALLGRIND_START_INSTRUMENTATION
- **Capture data:**

  CALLGRIND_TOGGLE_COLLECT
- **Stop simulation:**

  CALLGRIND_STOP_INSTRUMENTATION

Valgrind – How to profile

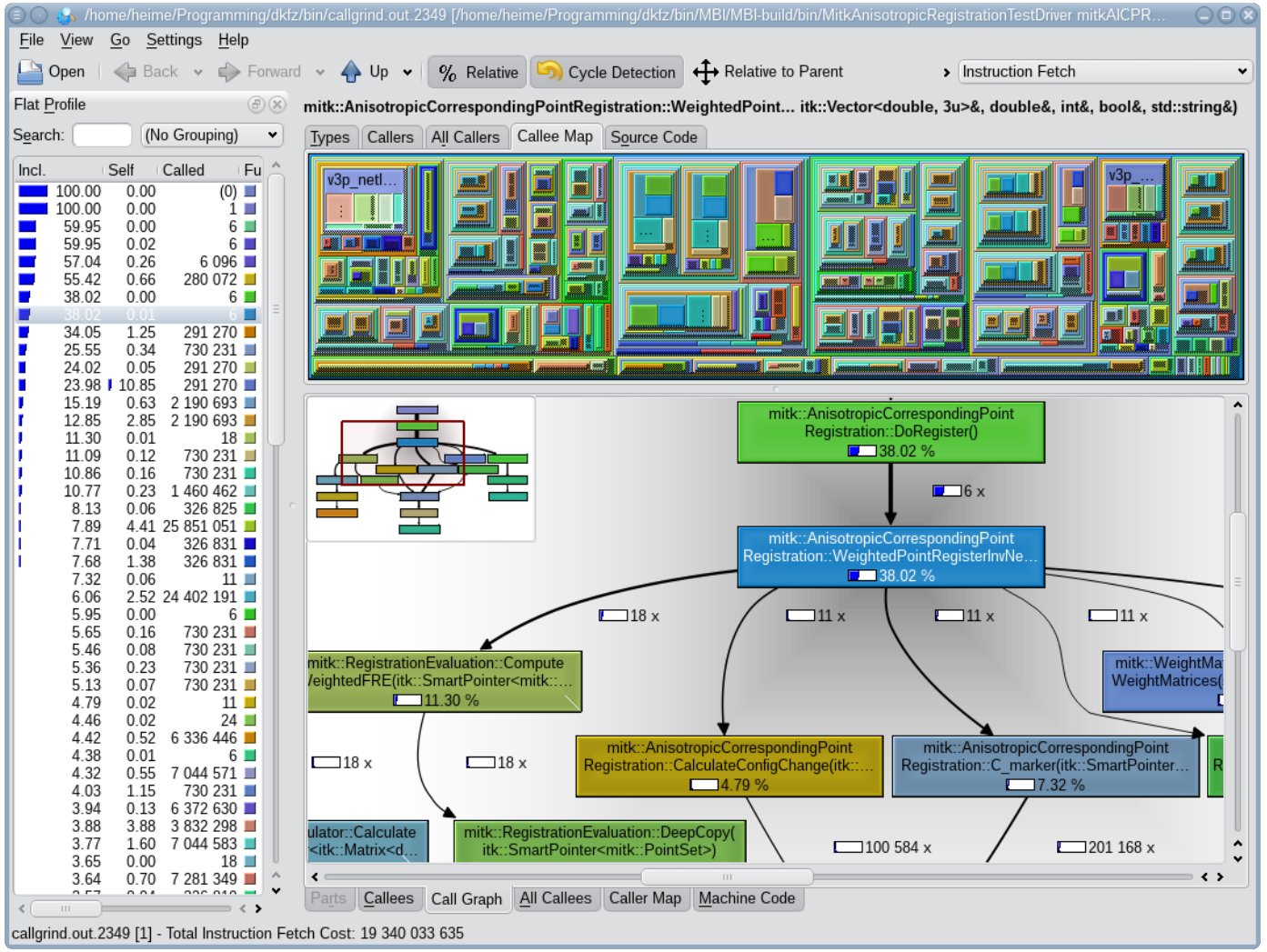
And finally we got our output:

```
20 ob=(7) /usr/lib/libstdc++.so.6.0.17
21 fl=(7) ???
22 fn=(298) std::future_category()
23 0xb2580 0 1 1 0 1 1 0 1 1
24 +7 0 1
25 jcnd=1/1 +17 0
26 * 0
27 +17 0 1
28 +7 0 1
29 +4 0 1 0 1
30 cfn=(304) __cxa_guard_acquire
31 calls=1 0x5f2f0 0
32 * 0 24 9 5 4 1 0 4
33 cob=(1) /usr/lib/ld-2.16.so
34 cfi=(1) ???
35 cfn=(166) _dl_runtime_resolve
36 calls=1 0x140e0 0
37 * 0 758 216 87 0 6 0 0 1
38 * 0 5 3 2 1 0 0 1
39 +5 0 1
40 +2 0 1
41 +2 0 1
42 +7 0 1 0 1
43 cfn=(310) std::error_category::error_category()
44 calls=1 0xb2a90 0
45 * 0 4 2 1 1 1 0 1
46 cob=(1)
47 cfi=(1)
48 cfn=(166)
49 calls=1 0x140e0 0
50 * 0 810 227 87 0 7
```

~17.000 lines for the simple program from the previous slides !!!

Valgrind – kcachegrind

Use kcachegrind to visualize and analyze the data.



Valgrind