Unwind Stack Frame in Real Time

Mu Lin

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Agenda

Objective

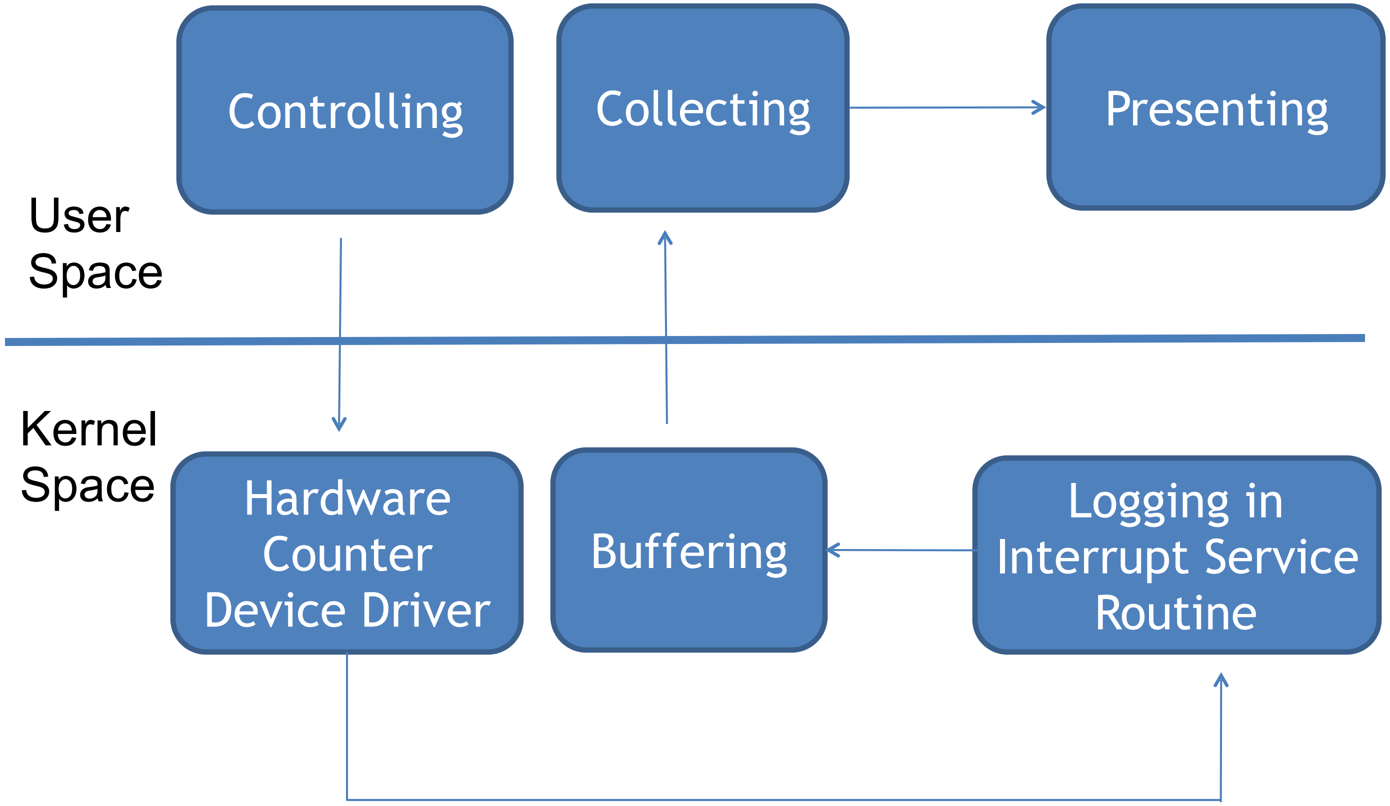
MIPS challenges

Solution --- scan backward from PC

Real time solution --- pre-processing and PC lookup

Q&A

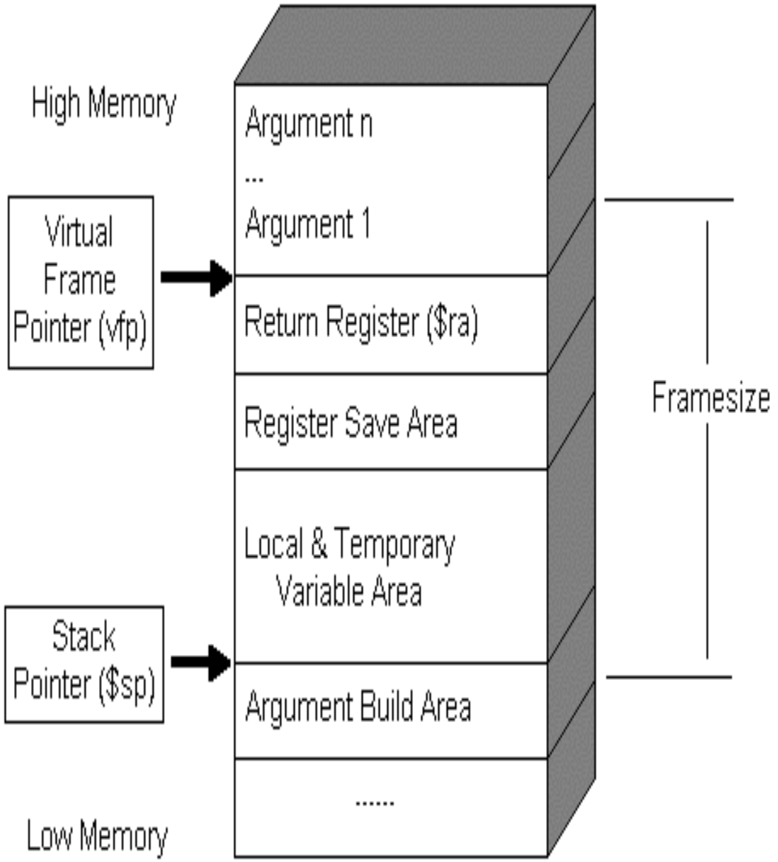
Components


Controlling
Collecting
Presenting
User Space
Kernel Space
Hardware Counter Device Driver
Buffering
Logging in Interrupt Service Routine

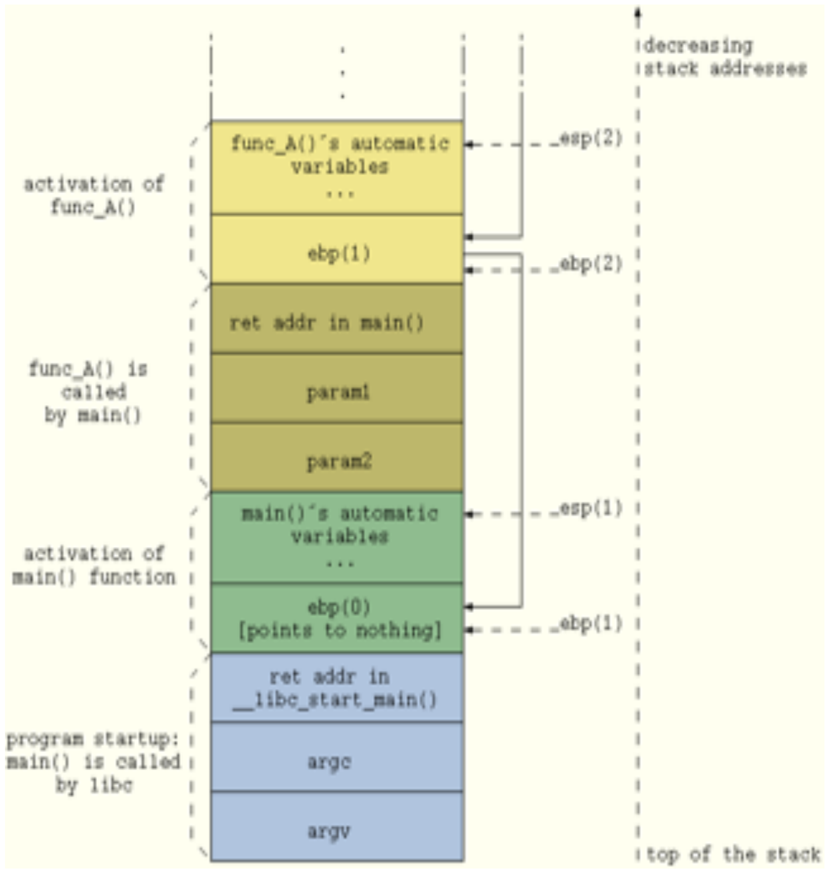
Sampling

- Periodically obtain call_graph (stack_trace) on the fly on clock_tick **when profiling.**
- The algorithm used in trap.c and gdb for MIPS will be used as the first step.
- The method/algorithm needs to be as light-weighted as possible, the "probe effect" or "top syndrome" (but there are limits and costs associated with optimization).

Why call graph is difficult for MIPS



MIPS


decreasing stack addresses
func_A()'s automatic variables ...
esp(2)
activation of func_A()
ebp(1)
ebp(2)
ret addr in main()
func_A() is called by main()
param1
param2
main()'s automatic variables ...
esp(1)
activation of main() function
ebp(0) [points to nothing]
ebp(1)
ret addr in __libc_start_main()
program startup: main() is called by libc
argc
argv
top of the stack

i386

GDB’s Solution

```
MIPS_Back_Trace() {
    Obtain SP, PC;
    Walk back from PC to find start_of_routine;
    Walk forward and decode instructions to find ra and stack_size;
    SP + stack_size; PC = ra; depth--;
    Repeat till ra==0 or depth == 0;
}
```

The prologue

```
00000174 <foo>:
174:   27bdffd8      addiu   sp,sp,-40
178:   afbf0024      sw      ra,36(sp)
17c:   afb00020      sw      s0,32(sp)
180:   3c1c0000      lui     gp,0x0
184:   279c0000      addiu   gp,gp,0
188:   afbc0010      sw      gp,16(sp)
18c:   00a08021      move    s0,a1
190:   8f990000      lw      t9,0(gp)
194:   0320f809      jalr    t9
198:   27a60018      addiu   a2,sp,24
19c:   10400002      beqz    v0, 1a8 <foo+0x34>
1a0:   8fbc0010      lw      gp,16(sp)
1a4:   ae000000      sw      zero,0(s0)
1a8:   8fbf0024      lw      ra,36(sp)
1ac:   8fb00020      lw      s0,32(sp)
1b0:   03e00008      jr      ra
1b4:   27bd0028      addiu   sp,sp,40
```

Solution

- MIPS’s function call overhead is quite expensive,

- we have more and more inline functions and longer functions in order to minimize function call overhead.

So, we may have a problem by linearly walking back from PC.

- Good news is We have a O(1) algorithm to find the start_of_routine from the given PC.

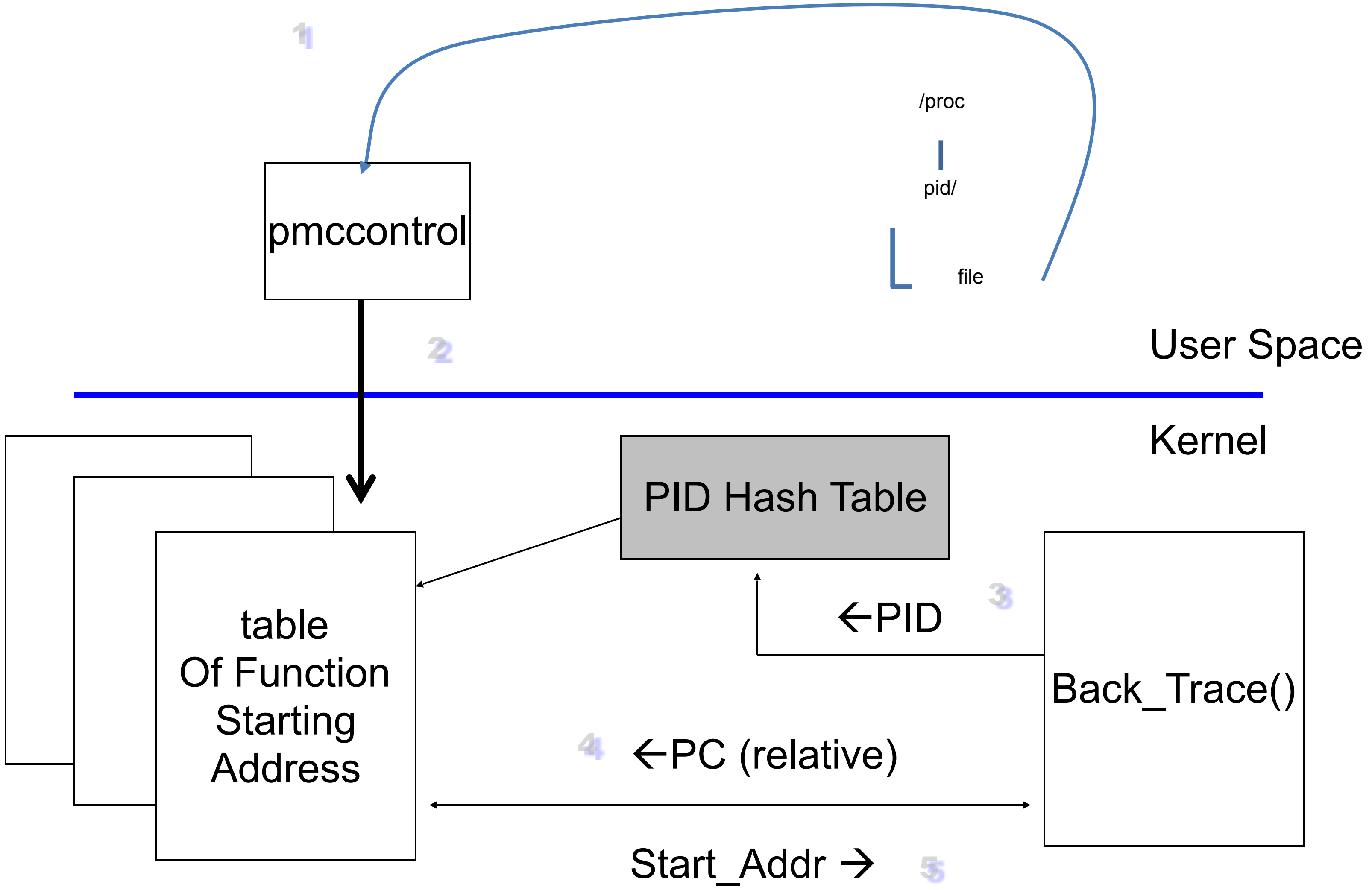
Real Time Solution

– Kernel keeps a table of starting_addr of routines for each targeted app.
– Do a indexed lookup to find the starting_addr for the given PC.

Take a typical daemon as example:

– Examine the symbol table or .pdr of the daemon, sort the function addresses and generate a compliant table to store the array.
– pmccontrol insert the table into kernel through ioctl() of /dev/pmc.
– Kernel keeps a hash-table to associate PID with the sorted arrays.

Solution Diagram



Multi-thread

- MIPS64 has two perf counters per core, but these counters are not virtualized.
- Thus for 4 VCPU per core, only two of them at one time can use the perf counters.
- Work around this using static thread pool.