Design and Engineering of Computer Systems Professor Mythili Vutukuru Computer Science and Engineering Indian Institute of Technology, Bombay Lecture 50 (Week 7, Tutorial 1) Basics of Perf

(Refer Slide Time: 0:16)



Hi everyone. In this video we will learn about Perf. Perf is a tool which offers a rich set of commands to collect and analyze performance data. If we want to know which parts of the programs are taking a lot of CPU time, then we can use perf. And let us open a terminal. And let us go through some of the very basic commands of perf. So, I will start with the stat command. Perf stat is used to collect statistics about any program. So, we can give it any command, let us say ls, and it will show us the statistics when ls is run. So, we will use sudo.

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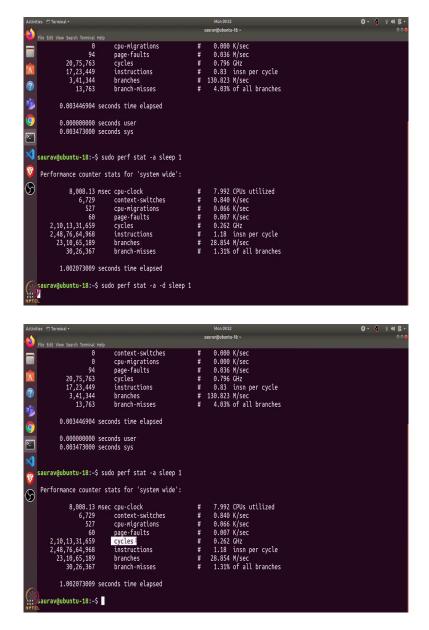


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20,75,763 cycles	# 0.796 GHz	
() 17,23,449 instructions 3,41,344 branches	# 0.83 insn per cycle	
	# 130.823 M/sec # 4.03% of all branches	
13,763 branch-misses	# 4.03% of all branches	
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<pre>saurav@ubuntu-18:~\$ sudo perf stat -a sleep 1</pre>		
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First, it executed ls and then it shows the counter statistics for ls, gives us how many context switches are there, how many CPU migrations page fault cycles, instructions et cetera. This is very basic use of perf to collect statistics about any program. Let us say we want to collect stats for the complete system. So, we want to collect statistics about every process that is running on any processor, we can use the -a flag to collect the statistics. And let us say we want to collect the statistics for one second, perf stat -a and then we can give it command sleep 1.

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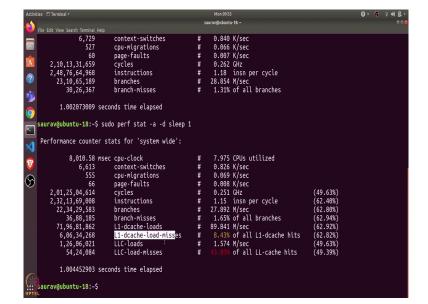
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🔞 sa	urav@ubuntu-18:~\$ s	udo perf stat -a sleep 1			
6 °	erformance counter	stats for 'system wide':			
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		ec cpu-clock	#	7.992 CPUs utilized	
	6,729	context-switches	#	0.840 K/sec	
	527	cpu-migrations	#	0.066 K/sec	
	60	page-faults	#	0.007 K/sec	
	2,10,13,31,659	cycles	#	0.262 GHz	
	2,48,76,64,968	instructions	#	1.18 insn per cycle	
	23,10,65,189	branches	#	28.854 M/sec	
	30,26,367	branch-misses	#	1.31% of all branches	
	1.002073009 se	conds time elapsed			
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So, this will count the statistics for 1 second. So, it says statistics for system wide. So, we have these many contracts, which is in one second, these many page faults, etc. And we can use the -d flag, get some detailed statistics.

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8	6,613	context-switches	#	0.826 K/sec			
	555	cpu-migrations	#	0.069 K/sec			
	66	page-faults	#	0.008 K/sec			
	2,01,25,04,614	cycles	#	0.251 GHz	(49.63%)		
	2,32,13,69,008	instructions	#	1.15 insn per cycle	(62.40%)		
	22,34,29,583	branches	#	27.892 M/sec	(62.80%)		
	36,88,185	branch-misses	#	1.65% of all branches	(62.94%)		
	71,96,81,862	L1-dcache-loads	#	89.841 M/sec	(62.92%)		
	6,06,34,268	L1-dcache-load-misses	#	8.43% of all L1-dcache hits	(62.82%)		
	1,26,06,021	LLC-loads	#	1.574 M/sec	(49.63%)		
	54,24,084	LLC-load-misses	#	43.03% of all LL-cache hits	(49.39%)		
	1.004452903 se	conds time elapsed					
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	54,24,084	LLC-load-misses	#	43.03% of all LL-cache hits	(49.39%)		
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(*)	aurav@ubuntu-18:~\$ su	do perf list					
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If I run it again, there, it shows us some other strategies such as L1 cache loads, L1 cache, load misses et cetera. Another important command that you can use with perf is perf list. So, if I run sudo perf list.

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It will list all the events that we can count using perf. So, it shows us some hardware events, such as branch instruction, branch misses, then there are some software events for which kernel maintains a counter, such as CPU migration, context switches. And then we have some cache events. This PMU refers to performance monitoring unit. So, there is a separate unit with the processor, which counts various hardware events, which include these branch instructions, or cache misses, et cetera.

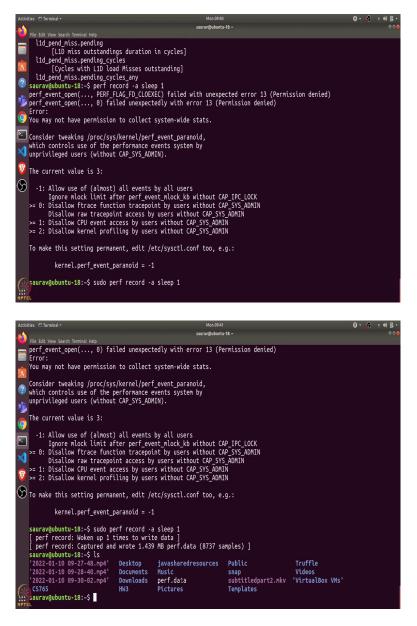
So, there are a lot of events, let us say want to measure certain event. For instance, let us try to measure these branch instructions.

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So, what we can do is we can use the -e flag. Let us say you want to measure branch instructions for 1 second, across all the processes, so I can use -e branch instructions. And then it will give me the count for the branch instructions for 1 second.

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The next command that we will see is perf report. Perf report is used to collect the profile data about a certain program in a separate file. So, let us say I want to record the data for complete system for 1 second, I need to use sudo. If we do ls, then we can see there is this perf.data file. This is a binary file, which stores the profiling data for our complete system.

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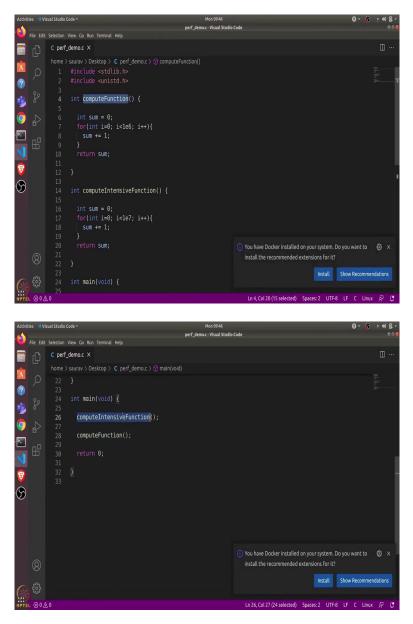
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0.61	% libobs: graphic	[i915]	<pre>[k] fw_domains_get_with_fallback</pre>	
		libx264.so.152	<pre>[.] x264_ratecontrol_mb_qp</pre>	
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0.31	% obs	libx264.so.152	<pre>[.] x264_macroblock_encode</pre>	
0.30	% obs	libx264.so.152	<pre>[.] x264_prefetch_fenc</pre>	
0.30	% alsa-source-CX8	[kernel.kallsyms]	<pre>[k] 0xfffffffa4cc1af2</pre>	
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So, how can we do this perf dot data file? We need to use perf report to read this binary file. Let us use perf report where input file perf.data. So, this shows us what is the percentage of CPU cycles that were used for this particular command and the shared object and so on. So, let us quit this using Q and let us try to profile some C program. So, I have written this perf demo dot c file. Let us first have a look at its contents.

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So, this is a very simple program. It has two functions. One is computeFunction, another is computeIntensiveFunction. And in the main function, we just call these two functions.

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			<pre>int computeIntensiveFunction() {</pre>			
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			int main(void) {			
			<pre>computeIntensiveFunction();</pre>			
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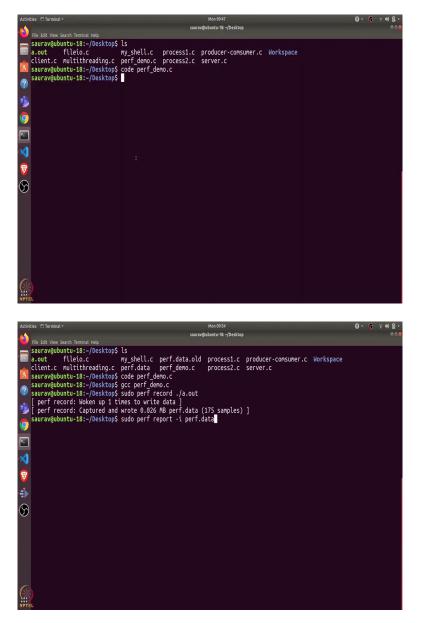
In the computeIntensiveFunction, we iterate 10 raise to 7 times, and we just add one to the sum a dummy variable and return that sum.

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In computeFunction, we iterate 10 raise to 6 times. So, computeIntensiveFunction uses 10 times more number of iterations then computeFunction.

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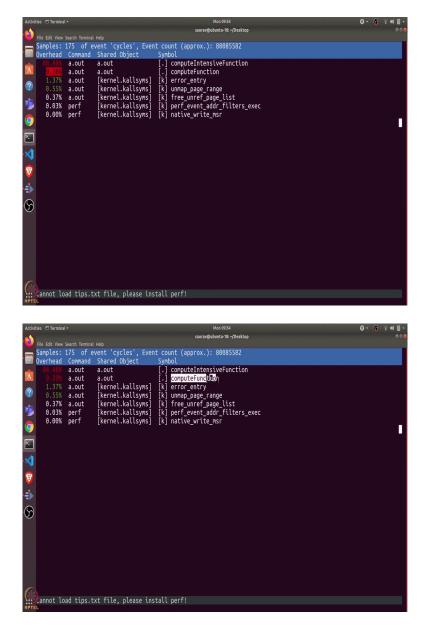
Let us try to compile this gcc perf_demo.c. And let us run the executable and try to profile it using perf. So, I will use sudo perf record ./a.out and this will generate the perf.data file. Now let us try to see the profile using sudo perf report -i perf.data.

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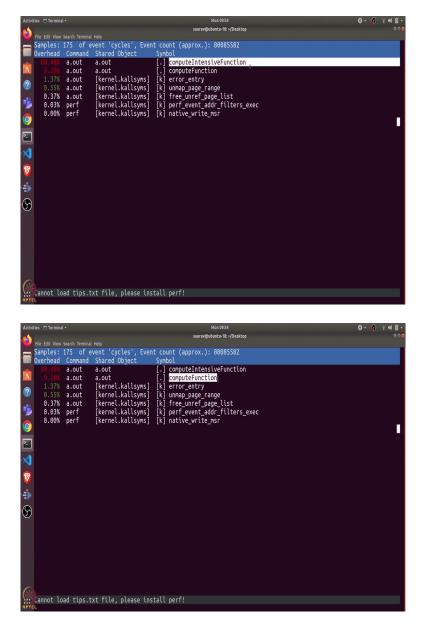
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Overhead Command Shared Object Image: Shared Object <td>Symbol [.] computeIntensiveFunction [.] computeIntensiveFunction [k] error_entry [k] unmap.page_range [k] free_unef_page_list [k] perf_event_addr_filters_exec [k] native_write_msr</td> <td></td>	Symbol [.] computeIntensiveFunction [.] computeIntensiveFunction [k] error_entry [k] unmap.page_range [k] free_unef_page_list [k] perf_event_addr_filters_exec [k] native_write_msr							
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86,48% a.out a.out 9,20% a.out a.out	<pre>[.] computeIntensiveFunction [.] computeFunction</pre>							
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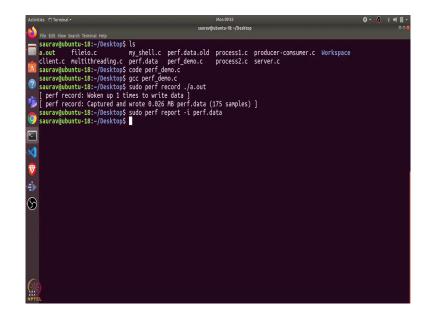
So, here it shows us the percentage of CPU that is used for various functions and the command that is a.out, and then the function name. Here we can see that almost 88 percent of CPU is used only in computeIntensiveFunction, and almost 9 percent is used in the computeFunction.

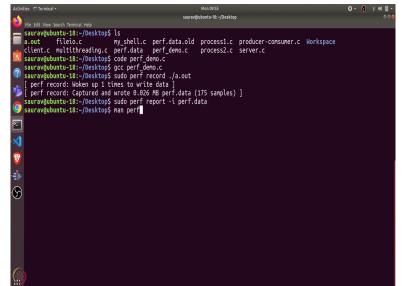
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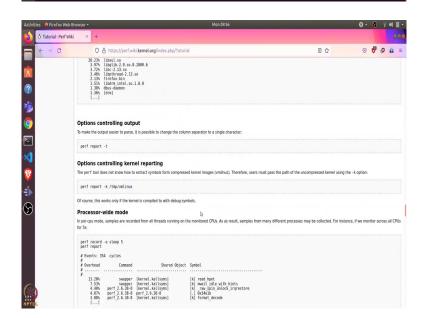


So, computeIntensiFunction is almost 10 times more expensive than compute function. And this also shows us what is the bottleneck of our program that is the computeIntensiveFunction.

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So, that is how we can profile various C programs and try to optimize their bottlenecks. If you want to see more details about perf then you can have a look at the man page of perf. And also there is a very nice tutorial on perf which you can find online. So, this explains various commands of perf, and what else you can do using perf. So, that is it for this video. Thanks and have a nice day.