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CPE315
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Lab 4 report

matadd -Pi	"-O0"	"-O1"	"-O2"	"-O3"
average CPI	1.428	1.408	1.408	1.408
Instructions	1590351045	1590433254	1590478014	1590489308
Branch-misses	6775088	6756745	6776176	6800759
Runtime (Measured)	2.508827214	2.547188766	2.471882517	2.50553201

Runtime (Equation): $CPU\ Time = \frac{Instructions}{Program} * \frac{Clock\ cycles}{Instruction} * \frac{Seconds}{clock\ cycle}$

The instruction count appears to increase as the optimization level increases. In terms of the CPI across the optimization levels, -O0 had a higher CPI, but the rest of the levels had the same CPI.

Amdahl's Law:

$$T_{improved} = \frac{T_{affected}}{improvement\ factor} + T_{unaffected}$$

Unroll 2:

$$2.471 = \frac{0.96}{improvement\ factor} + 1.527 \rightarrow improvement\ factor = 1.01$$

Unroll 4:

$$2.335 = \frac{0.96}{improvement\ factor} + 1.527 \rightarrow improvement\ factor = 1.18$$

Unroll 8:

$$2.113 = \frac{0.96}{improvement\ factor} + 1.527 \rightarrow improvement\ factor = 1.64$$

performance equation:

$$performance = \frac{1}{execution\ time}$$

$$execution\ time = \frac{1}{performance}$$

	Measured Runtimes (s)	Expected Runtimes (s)
Unroll 0	2.547	N/A
Unroll 2	2.471	$\frac{1}{2}(2.547) = 1.2735$

Unroll 4	2.335	$\frac{1}{4}(2.547) = 0.637$
Unroll 8	2.113	$\frac{1}{8}(2.547) = 0.318$

We expected the performance to decrease significantly due to decreasing the number of times the process would have to loop through. We suspect that our expected times differ from our measured times because we did not take into account the fixed time the process takes that is unaffected by reducing the number of loops

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-O0 optimization

Performance counter stats for './matadd':

2006.575686	task-clock:u (msec)	#	0.788 CPUs utilized
0	context-switches:u	#	0.000 K/sec
0	cpu-migrations:u	#	0.000 K/sec
3,179	page-faults:u	#	0.002 M/sec
2,274,136,742	cycles:u	#	1.133 GHz
1,590,433,254	instructions:u	#	0.70 insn per cycle
109,073,860	branches:u	#	54.358 M/sec
6,756,745	branch-misses:u	#	6.19% of all branches

2.547188766 seconds time elapsed

-O1 optimization

Performance counter stats for './matadd':

1970.231200	task-clock:u (msec)	#	0.785 CPUs utilized
0	context-switches:u	#	0.000 K/sec
0	cpu-migrations:u	#	0.000 K/sec
3,178	page-faults:u	#	0.002 M/sec
2,252,425,702	cycles:u	#	1.143 GHz
1,590,351,045	instructions:u	#	0.71 insn per cycle
109,070,137	branches:u	#	55.359 M/sec
6,775,088	branch-misses:u	#	6.21% of all branches

2.508827214 seconds time elapsed

-O1 optimization gprof

Flat profile:

Each sample counts as 0.01 seconds.

% time	cumulative seconds	self seconds	calls	self Ts/call	total Ts/call	name
93.79	1.02	1.02				matadd
5.52	1.08	0.06				AllocateMatrix(unsigned in
						t, unsigned int, int)
0.92	1.09	0.01				PrintMat(int**, unsigned i
						nt, unsigned int)

-O2 optimization

Performance counter stats for './matadd':

1932.726250	task-clock:u (msec)	#	0.782 CPUs utilized
0	context-switches:u	#	0.000 K/sec
0	cpu-migrations:u	#	0.000 K/sec
3,179	page-faults:u	#	0.002 M/sec
2,254,383,970	cycles:u	#	1.166 GHz
1,590,478,014	instructions:u	#	0.71 insn per cycle
109,066,150	branches:u	#	56.431 M/sec
6,776,176	branch-misses:u	#	6.21% of all branches

2.471882517 seconds time elapsed

-O3 optimization

Performance counter stats for './matadd':

1964.987917	task-clock:u (msec)	#	0.784 CPUs utilized
0	context-switches:u	#	0.000 K/sec
0	cpu-migrations:u	#	0.000 K/sec
3,178	page-faults:u	#	0.002 M/sec
2,254,348,169	cycles:u	#	1.147 GHz
1,590,489,308	instructions:u	#	0.71 insn per cycle
109,066,171	branches:u	#	55.505 M/sec
6,800,759	branch-misses:u	#	6.24% of all branches

2.505532010 seconds time elapsed

-O1 optimization Loop Unrolling Level 2

Performance counter stats for './matadd':

1935.412505	task-clock:u (msec)	#	0.783 CPUs utilized
0	context-switches:u	#	0.000 K/sec
0	cpu-migrations:u	#	0.000 K/sec
3,177	page-faults:u	#	0.002 M/sec
2,201,321,099	cycles:u	#	1.137 GHz
1,538,061,369	instructions:u	#	0.70 insn per cycle
98,580,419	branches:u	#	50.935 M/sec
6,671,582	branch-misses:u	#	6.77% of all branches

2.471354752 seconds time elapsed

-O1 optimization Loop Unrolling Level 2 gprof

Flat profile:

Each sample counts as 0.01 seconds.

% time	cumulative seconds	self seconds	calls	self Ts/call	total Ts/call	name
95.15	0.98	0.98				matadd
2.91	1.01	0.03				AllocateMatrix(unsigned in
						t, unsigned int, int)
1.94	1.03	0.02				PrintMat(int**, unsigned i
						nt, unsigned int)

-O1 optimization Loop Unrolling Level 4

Performance counter stats for './matadd':

1877.228652	task-clock:u (msec)	#	0.804 CPUs utilized
0	context-switches:u	#	0.000 K/sec
0	cpu-migrations:u	#	0.000 K/sec
3,179	page-faults:u	#	0.002 M/sec
2,158,485,081	cycles:u	#	1.150 GHz
1,493,897,981	instructions:u	#	0.69 insn per cycle
92,842,860	branches:u	#	49.457 M/sec
6,796,630	branch-misses:u	#	7.32% of all branches

2.335283512 seconds time elapsed

-O1 optimization Loop Unrolling Level 4 gprof

Flat profile:

Each sample counts as 0.01 seconds.

% time	cumulative seconds	self seconds	calls	self Ts/call	total Ts/call	name
97.96	0.96	0.96				matadd
2.04	0.98	0.02				AllocateMatrix(unsigned in t, unsigned int, int)

-O1 optimization Loop Unrolling Level 8

Performance counter stats for './matadd':

1879.326156	task-clock:u (msec)	#	0.889 CPUs utilized
0	context-switches:u	#	0.000 K/sec
0	cpu-migrations:u	#	0.000 K/sec
3,178	page-faults:u	#	0.002 M/sec
2,156,355,397	cycles:u	#	1.147 GHz
1,489,722,384	instructions:u	#	0.69 insn per cycle
90,468,457	branches:u	#	48.139 M/sec
6,759,146	branch-misses:u	#	7.47% of all branches

2.113450258 seconds time elapsed

-O1 optimization Loop Unrolling Level 8 gprof

Flat profile:

Each sample counts as 0.01 seconds.

% time	cumulative seconds	self seconds	calls	self Ts/call	total Ts/call	name
95.05	0.96	0.96				matadd
4.95	1.01	0.05				AllocateMatrix(unsigned in t, unsigned int, int)