CS422: Computer Architecture

Homework 1

Implementation Details

Our implementation uses fast-forwarding at the basic block level, and we have also tried to incorporate the actual analysis at the basic block level to the maximum extent possible.

To keep analysis calls slim, the calls simply increment the number of times a certain basic block is run, and almost all the relevant counting is done in the exit routine.

One aspect which cannot be dealt with this basic block counting method is the data memory footprint. As the memory operands can be dynamic, they have to be dealt with during analysis and also at the instruction-level.

Dumping all memory accesses and then processing them in the exit routine is sub-optimal as the dump will consume a lot of memory for any realistic application running for a long enough period of time. The other obvious option is to keep an array/bitset for all possible memory addresses. This is even more sub-optimal as we need a very big array/bitset, which would be completely impossible for 64 bit benchmarks if we had any.

To reduce the memory footprint of the pin tool, one would have to use some sort of a data structure to only log unique memory addresses. The obvious option would be a set, but it comes with a drawback - set insert calls at the time of analysis would be costly.

The final solution we have implemented mimics the paging scheme of x86 using arrays - the idea is that we just want a bitset which can track which addresses we have touched, but large parts of the bitset will simply go unused. So, we implement a page directory/page table structure using arrays, and upon encountering an address corresponding to an unmapped page we allocate one by incrementing a few counters here and there. If there is not enough space to allocate a new page, we realloc() our arrays.

This scheme comes with the advantage of a low memory footprint, while being fast as well. If the page exists the analysis call is simply setting an array value to 1 after a few indirections. The OS and compiler will anyway keep the memory addresses limited to not too many pages, hence the costlier operations occur very rarely.

The overall pin tool takes about 5-6 mins to run on perlbench.

The final results are reported on a server with 8 threads, and 32 GB RAM. The processor used is - AMD EPYC-Milan Processor

Benchmark Results

400.perlbench diffmail.pl

Part A

Instruction Type	Absolute Value	Percentage
Instruction Count	1000000001	-
Loads	356838743	22.83%
Stores	205970465	13.18%
NOPs	959563	0.06%
Direct Calls	12742485	0.82%
Indirect Calls	2839560	0.18%
Returns	15582046	1.00%
Unconditional Branches	30549008	1.95%
Conditional Branches	129984042	8.32%
Logical operations	100106278	6.41%
Rotate and Shift	4275188	0.27%
Flag Operations	862091	0.06%
Vector Instructions	0	0.00%
Conditional Moves	0	0.00%
MMX and SSE instructions	0	0.00%
System Calls	0	0.00%
Floating Point Instructions	933010	0.06%
The rest	701166731	44.87%

Part B

CPI: 25.84874

Part C

Data Chunk Accesses: 31101
Instruction Chunk Accesses: 2810

Part D

Distribution of Instruction Length

Bytes	Count
0	0
1	117382740
2	256612066
3	274772730
4	52905377
5	78567185
6	185781333
7	33978530
8	28
9	0
10	12
11	0
12	0
13	0
14	0
15	0

Distribution of the number of operands in an instruction

Operands	Count
0	959563
1	1072479
2	520827030
3	355062689
4	103215352
5	15583706
6	3279182
7	0
8	0
9	0

Distribution of the number of register read operands in an instruction

Reads	Count
0	10082890
1	260353245
2	537426194
3	179162162
4	7097158
5	2599170
6	3279182
7	0
8	0
9	0

Distribution of the number of register write operands in an instruction

Writes	Count
0	135800450
1	685177102
2	175739723
3	2394388
4	888338
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory operands in an instruction

Operands	Count
0	453635188
1	530799022
2	15565791
3	0

Operands	Count
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory read operands in an instruction

Operands	Count
0	190659134
1	354817364
2	888315
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory write operands in an instruction

Operands	Count
0	341028203
1	205336610
2	0
3	0
4	0
5	0
6	0
7	0
8	0

Operands	Count
9	0

Maximum number of bytes touched by an instruction: 8
Average number of bytes touched by an instruction: 3.73807
Maximum value of immediate: 2147483647
Minimum value of immediate: -2147483648
Maximum value of displacement used in memory addressing: 135918104
Minimum value of displacement used in memory addressing: -1408

401.bzip2 input.source

Part A

Instruction Type	Absolute Value	Percentage
Instruction Count	1000000000	-
Loads	452710229	26.88%
Stores	231178146	13.73%
NOPs	36514	0.00%
Direct Calls	791604	0.05%
Indirect Calls	13	0.00%
Returns	791614	0.05%
Unconditional Branches	21299210	1.26%
Conditional Branches	129923144	7.72%
Logical operations	71000704	4.22%
Rotate and Shift	61831941	3.67%
Flag Operations	6130	0.00%
Vector Instructions	0	0.00%
Conditional Moves	0	0.00%
MMX and SSE instructions	0	0.00%
System Calls	0	0.00%
Floating Point Instructions	0	0.00%
The rest	714319126	42.42%

Part B

CPI: 29.02341

Part C

Data Chunk Accesses: 2441019
Instruction Chunk Accesses: 754

Part D

Distribution of Instruction Length

Bytes	Count
0	0
1	38611261
2	219201458
3	436965530
4	75327011
5	22047524
6	141357374
7	51341600
8	15085632
9	0
10	62610
11	0
12	0
13	0
14	0
15	0

Distribution of the number of operands in an instruction

Operands	Count
0	36514
1	6147
2	597647448
3	382870411
4	2693869
5	14191403
6	2554208
7	0
8	0
9	0

Distribution of the number of register read operands in an instruction

Reads	Count
0	5189068
1	183351652
2	533608125
3	215105844
4	46791304
5	13399799
6	2554208
7	0
8	0
9	0

Distribution of the number of register write operands in an instruction

Writes	Count
0	132331400
1	712782483
2	152331892
3	2554225
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory operands in an instruction

Operands	Count
0	399856582
1	516406617
2	83736801
3	0
4	0

Operands	Count
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory read operands in an instruction

Operands	Count
0	147437265
1	452706153
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory write operands in an instruction

Operands	Count
0	368969352
1	231174066
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Maximum number of bytes touched by an instruction: 8
Average number of bytes touched by an instruction: 3.48541
Maximum value of immediate: 1431655766
Minimum value of immediate: -858993459
Maximum value of displacement used in memory addressing: 135000192
Minimum value of displacement used in memory addressing: -4848

403.gcc cp-decl.i

Part A

Instruction Type	Absolute Value	Percentage
Instruction Count	999999998	-
Loads	138311348	9.24%
Stores	359267344	23.99%
NOPs	189282	0.01%
Direct Calls	4590551	0.31%
Indirect Calls	501863	0.03%
Returns	5092413	0.34%
Unconditional Branches	4934339	0.33%
Conditional Branches	133478830	8.91%
Logical operations	131969278	8.81%
Rotate and Shift	2349699	0.16%
Flag Operations	184910	0.01%
Vector Instructions	0	0.00%
Conditional Moves	0	0.00%
MMX and SSE instructions	0	0.00%
System Calls	0	0.00%
Floating Point Instructions	5	0.00%
The rest	716708828	47.86%

Part B

CPI: 23.92563

Part C

Data Chunk Accesses: 1140752
Instruction Chunk Accesses: 2953

Part D

Distribution of Instruction Length

Bytes	Count
0	0
1	129831292
2	591656217
3	124866097
4	115982272
5	11208076
6	15635333
7	10762372
8	58339
9	0
10	0
11	0
12	0
13	0
14	0
15	0

Distribution of the number of operands in an instruction

Operands	Count
0	189282
1	4598587
2	349464457
3	403930536
4	33847780
5	203714073
6	4255283
7	0
8	0
9	0

Distribution of the number of register read operands in an instruction

Reads	Count
0	2136960
1	168992759
2	472424311
3	62601062
4	90467499
5	199122124
6	4255283
7	0
8	0
9	0

Distribution of the number of register write operands in an instruction

Writes	Count
0	125743996
1	418779303
2	451078536
3	4398163
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory operands in an instruction

Operands	Count
0	518888091
1	464713530
2	16398377
3	0
4	0

Operands	Count
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory read operands in an instruction

Operands	Count
0	342800562
1	138311345
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory write operands in an instruction

Opernads	Count
0	121912968
1	359198939
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Maximum number of bytes touched by an instruction: 8
Average number of bytes touched by an instruction: 3.95864
Maximum value of immediate: 1073741823
Minimum value of immediate: -2147483587
Maximum value of displacement used in memory addressing: 138634432
Minimum value of displacement used in memory addressing: -1744

429.mcf

Part A

Instruction Type	Absolute Value	Percentage
Instruction Count	999999995	-
Loads	415212714	27.22%
Stores	110040152	7.21%
NOPs	1477639	0.10%
Direct Calls	12556301	0.82%
Indirect Calls	0	0.00%
Returns	12556300	0.82%
Unconditional Branches	8314496	0.55%
Conditional Branches	178243015	11.69%
Logical operations	75119495	4.93%
Rotate and Shift	3516416	0.23%
Flag Operations	0	0.00%
Vector Instructions	0	0.00%
Conditional Moves	0	0.00%
MMX and SSE instructions	0	0.00%
System Calls	0	0.00%
Floating Point Instructions	0	0.00%
The rest	708216333	46.43%

Part B

CPI: 24.76160

Part C

Data Chunk Accesses: 11672843
Instruction Chunk Accesses: 66

Part D

Distribution of Instruction Length

Bytes	Count
0	0
1	80626429
2	485393436
3	315526342
4	50531205
5	22076550
6	5249820
7	40536213
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0

Distribution of the number of operands in an instruction

Operands	Count
0	1477639
1	0
2	484784798
3	457347095
4	43834162
5	12556301
6	0
7	0
8	0
9	0

Distribution of the number of register read operands in an instruction

Reads	Count
0	3759879
1	148510619
2	677530557
3	170198940
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of register write operands in an instruction

Writes	Count
0	70906605
1	770283672
2	158771206
3	38512
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory operands in an instruction

Operands	Count
0	487182329
1	500382455
2	12435211
3	0
4	0

Operands	Count
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory read operands in an instruction

Operands	Count
0	97604946
1	415212720
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory write operands in an instruction

Operands	Count
0	402777509
1	110040157
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Maximum number of bytes touched by an instruction: 4
Average number of bytes touched by an instruction: 4.00
Maximum value of immediate: 1374389535
Minimum value of immediate: -100000000
Maximum value of displacement used in memory addressing: 134957120
Minimum value of displacement used in memory addressing: -76

450.soplex ref.mps

Part A

Instruction Type	Absolute Value	Percentage
Instruction Count	999999995	-
Loads	547816765	33.27%
Stores	98782934	6.00%
NOPs	3550	0.00%
Direct Calls	3177232	0.19%
Indirect Calls	111	0.00%
Returns	3177343	0.19%
Unconditional Branches	12754267	0.77%
Conditional Branches	103254427	6.27%
Logical operations	13997730	0.85%
Rotate and Shift	10484108	0.64%
Flag Operations	22967932	1.39%
Vector Instructions	0	0.00%
Conditional Moves	0	0.00%
MMX and SSE instructions	0	0.00%
System Calls	0	0.00%
Floating Point Instructions	309501735	18.80%
The rest	520681560	31.62%

Part B

CPI: 28.09546

Part C

Data Chunk Accesses: 5658598
Instruction Chunk Accesses: 646

Part D

Distribution of Instruction Length

Bytes	Count
0	0
1	77591041
2	441944595
3	399698003
4	16087417
5	3219650
6	40002789
7	17519588
8	3936912
9	0
10	0
11	0
12	0
13	0
14	0
15	0

Distribution of the number of operands in an instruction

Operands	Count
0	3550
1	13
2	412391793
3	396045259
4	188350993
5	3208387
6	0
7	0
8	0
9	0

Distribution of the number of register read operands in an instruction

Reads	Count
0	23142637
1	216228422
2	578652863
3	137989682
4	43955254
5	31137
6	0
7	0
8	0
9	0

Distribution of the number of register write operands in an instruction

Writes	Count
0	68172486
1	765092947
2	166734562
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory operands in an instruction

Operands	Count
0	531479062
1	439276467
2	29244466
3	0
4	0

Operands	Count
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory read operands in an instruction

Operands	Count
0	51702071
1	416818862
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory write operands in an instruction

Operands	Count
0	387574396
1	80946537
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Maximum number of bytes touched by an instruction: 8
Average number of bytes touched by an instruction: 5.27066
Maximum value of immediate: 2147483647
Minimum value of immediate: -640172613
Maximum value of displacement used in memory addressing: 135855532
Minimum value of displacement used in memory addressing: -344

456.hmmer nph3.hmm

Part A

Instruction Type	Absolute Value	Percentage
Instruction Count	1000000001	-
Loads	547671722	33.74%
Stores	75699710	4.66%
NOPs	34317	0.00%
Direct Calls	144622	0.01%
Indirect Calls	959	0.00%
Returns	145581	0.01%
Unconditional Branches	205862	0.01%
Conditional Branches	144361425	8.89%
Logical operations	1158703	0.07%
Rotate and Shift	294106	0.02%
Flag Operations	5669	0.00%
Vector Instructions	0	0.00%
Conditional Moves	0	0.00%
MMX and SSE instructions	0	0.00%
System Calls	0	0.00%
Floating Point Instructions	40212	0.00%
The rest	853608545	52.58%

Part B

CPI: 27.49586

Part C

Data Chunk Accesses: 84052
Instruction Chunk Accesses: 486

Part D

Distribution of Instruction Length

Bytes	Count
0	0
1	25078459
2	302860552
3	296150918
4	270388796
5	24861234
6	68360207
7	416480
8	11883355
9	0
10	0
11	0
12	0
13	0
14	0
15	0

Distribution of the number of operands in an instruction

Operands	Count
0	34887
1	3512
2	566126763
3	432938365
4	713115
5	159551
6	23808
7	0
8	0
9	0

Distribution of the number of register read operands in an instruction

Reads	Count
0	610947
1	75620185
2	562398800
3	281425794
4	79905538
5	14929
6	23808
7	0
8	0
9	0

Distribution of the number of register write operands in an instruction

Writes	Count
0	75149179
1	755279998
2	169547016
3	23808
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory operands in an instruction

Operands	Count
0	376809117
1	623024775
2	166109
3	0
4	0

Operands	Count
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory read operands in an instruction

Operands	Count
0	75528003
1	547662881
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory write operands in an instruction

Operands	Count
0	547496772
1	75694112
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Maximum number of bytes touched by an instruction: 8
Average number of bytes touched by an instruction: 3.99751
Maximum value of immediate: 2147483647
Minimum value of immediate: -987654321
Maximum value of displacement used in memory addressing: 135294312
Minimum value of displacement used in memory addressing: -580

471.omnetpp

Part A

Instruction Type	Absolute Value	Percentage
Instruction Count	1000000004	-
Loads	371235139	23.19%
Stores	229791102	14.35%
NOPs	802403	0.05%
Direct Calls	21327723	1.33%
Indirect Calls	3689258	0.23%
Returns	25016982	1.56%
Unconditional Branches	22189666	1.39%
Conditional Branches	117335247	7.33%
Logical operations	60009446	3.75%
Rotate and Shift	7139686	0.45%
Flag Operations	20159872	1.26%
Vector Instructions	0	0.00%
Conditional Moves	0	0.00%
MMX and SSE instructions	0	0.00%
System Calls	0	0.00%
Floating Point Instructions	96963587	6.06%
The rest	625366134	39.06%

Part B

CPI: 26.90264

Part C

Data Chunk Accesses: 528736
Instruction Chunk Accesses: 891

Part D

Distribution of Instruction Length

Bytes	Count
0	0
1	154578800
2	308551256
3	382074579
4	34347873
5	45117268
6	48822851
7	26506956
8	0
9	0
10	421
11	0
12	0
13	0
14	0
15	0

Distribution of the number of operands in an instruction

Operands	Count
0	802403
1	225879
2	518294369
3	281743910
4	172763956
5	25030572
6	1138915
7	0
8	0
9	0

Distribution of the number of register read operands in an instruction

Reads	Count
0	29000202
1	197518845
2	540431949
3	219765979
4	8457503
5	3686611
6	1138915
7	0
8	0
9	0

Distribution of the number of register write operands in an instruction

Writes	Count
0	165349972
1	665542439
2	167592664
3	376014
4	1138915
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory operands in an instruction

Operands	Count
0	449250115
1	542984766
2	7765123
3	0
4	0

Operands	Count
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory read operands in an instruction

Operands	Count
0	212450802
1	337160172
2	1138915
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory write operands in an instruction

Operands	Count
0	331672879
1	219077010
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Maximum number of bytes touched by an instruction: 8
Average number of bytes touched by an instruction: 4.22175
Maximum value of immediate: 2147483647
Minimum value of immediate: -2092037281
Maximum value of displacement used in memory addressing: 136090116
Minimum value of displacement used in memory addressing: -104

483.xalancbmk

Part A

Instruction Type	Absolute Value	Percentage
Instruction Count	999999999	-
Loads	368285554	23.95%
Stores	169743280	11.04%
NOPs	22004073	1.43%
Direct Calls	13270384	0.86%
Indirect Calls	8947553	0.58%
Returns	22216327	1.44%
Unconditional Branches	8619037	0.56%
Conditional Branches	177692163	11.55%
Logical operations	37949205	2.47%
Rotate and Shift	5621502	0.37%
Flag Operations	1675102	0.11%
Vector Instructions	0	0.00%
Conditional Moves	0	0.00%
MMX and SSE instructions	0	0.00%
System Calls	0	0.00%
Floating Point Instructions	7312742	0.48%
The rest	694691911	45.17%

Part B

CPI: 25.13738

Part C

Data Chunk Accesses: 838186
Instruction Chunk Accesses: 2299

Part D

Distribution of Instruction Length

Bytes	Count
0	0
1	145417397
2	320264376
3	446452310
4	31889277
5	24145344
6	23732563
7	7709324
8	262554
9	60557
10	66297
11	0
12	0
13	0
14	0
15	0

Distribution of the number of operands in an instruction

Operands	Count
0	22004073
1	748204
2	423137418
3	412389160
4	102000945
5	24177375
6	15542824
7	0
8	0
9	0

Distribution of the number of register read operands in an instruction

Reads	Count
0	29470106
1	236655527
2	457874007
3	250423600
4	1205380
5	8828555
6	15542824
7	0
8	0
9	0

Distribution of the number of register write operands in an instruction

Writes	Count
0	113551163
1	685190722
2	185713783
3	15544331
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory operands in an instruction

Operands	Count
0	493479671
1	479447201
2	27073127
3	0
4	0

Operands	Count
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory read operands in an instruction

Operands	Count
0	141051745
1	365468583
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory write operands in an instruction

Operands	Count
0	338395456
1	168124872
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Maximum number of bytes touched by an instruction: 8
Average number of bytes touched by an instruction: 4.15831
Maximum value of immediate: 2147483647
Minimum value of immediate: -1431655765
Maximum value of displacement used in memory addressing: 139657912
Minimum value of displacement used in memory addressing: -1392

Optional Benchmarks

436.cactusADM

Part A

Instruction Type	Absolute Value	Percentage
Instruction Count	1000000025	-
Loads	1040837004	43.88%
Stores	331288182	13.97%
NOPs	2265	0.00%
Direct Calls	531584	0.02%
Indirect Calls	193	0.00%
Returns	531777	0.02%
Unconditional Branches	535271	0.02%
Conditional Branches	4305620	0.18%
Logical operations	1626453	0.07%
Rotate and Shift	1059310	0.04%
Flag Operations	5	0.00%
Vector Instructions	0	0.00%
Conditional Moves	0	0.00%
MMX and SSE instructions	0	0.00%
System Calls	0	0.00%
Floating Point Instructions	851723546	35.90%
The rest	139684001	5.89%

Part B

CPI: 40.91289

Part C

Data Chunk Accesses: 4378243
Instruction Chunk Accesses: 1225

Part D

Distribution of Instruction Length

Bytes	Count
0	0
1	1658078
2	263441920
3	78112037
4	15678306
5	1609528
6	603728417
7	35771739
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0

Distribution of the number of operands in an instruction

Operands	Count
0	2265
1	23
2	83585145
3	461382409
4	454498376
5	531777
6	30
7	0
8	0
9	0

Distribution of the number of register read operands in an instruction

Reads	Count
0	182747783
1	42914499
2	532137882
3	397790818
4	8881878
5	135
6	30
7	0
8	0
9	0

Distribution of the number of register write operands in an instruction

Writes	Count
0	149849538
1	791740403
2	58409928
3	126
4	30
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory operands in an instruction

Operands	Count
0	273540897
1	690600411
2	35858717
3	0

Operands	Count
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory read operands in an instruction

Operands	Count
0	150924591
1	575534507
2	30
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory write operands in an instruction

Operands	Count
0	539675850
1	186783278
2	0
3	0
4	0
5	0
6	0
7	0
8	0

Operands	Count
9	0

Maximum number of bytes touched by an instruction: 8
Average number of bytes touched by an instruction: 7.35779
Maximum value of immediate: 1431655766
Minimum value of immediate: -2147483648
Maximum value of displacement used in memory addressing: 135701372
Minimum value of displacement used in memory addressing: -2620

437.leslie3d

Part A

Instruction Type	Absolute Value	Percentage
Instruction Count	999999974	-
Loads	736425922	38.01%
Stores	201007390	10.37%
NOPs	83321	0.00%
Direct Calls	913	0.00%
Indirect Calls	17	0.00%
Returns	930	0.00%
Unconditional Branches	169181	0.01%
Conditional Branches	41549285	2.14%
Logical operations	435798	0.02%
Rotate and Shift	5168464	0.27%
Flag Operations	32	0.00%
Vector Instructions	0	0.00%
Conditional Moves	0	0.00%
MMX and SSE instructions	0	0.00%
System Calls	0	0.00%
Floating Point Instructions	394808052	20.38%
The rest	557783981	28.79%

Part B

CPI: 34.38587

Part C

Data Chunk Accesses: 2455850
Instruction Chunk Accesses: 2632

Part D

Distribution of Instruction Length

Bytes	Count
0	0
1	34716289
2	503707191
3	58913112
4	82555
5	412264
6	400346767
7	1821778
8	0
9	0
10	18
11	0
12	0
13	0
14	0
15	0

Distribution of the number of operands in an instruction

Operands	Count
0	83321
1	33
2	317860956
3	492867782
4	189186846
5	992
6	44
7	0
8	0
9	0

Distribution of the number of register read operands in an instruction

Reads	Count
0	357048
1	58705861
2	653895054
3	270599963
4	16441932
5	72
6	44
7	0
8	0
9	0

Distribution of the number of register write operands in an instruction

Writes	Count
0	68909634
1	735959862
2	195130320
3	158
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory operands in an instruction

Operands	Count
0	378021898
1	548828586
2	73149490
3	0
4	0

Operands	Count
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory read operands in an instruction

Operands	Count
0	68829595
1	553148481
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory write operands in an instruction

Operands	Count
0	479998991
1	141979085
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Maximum number of bytes touched by an instruction: 10
Average number of bytes touched by an instruction: 5.55829
Maximum value of immediate: 2147483647
Minimum value of immediate: -2147483648
Maximum value of displacement used in memory addressing: 135182404
Minimum value of displacement used in memory addressing: -1760

462.libquantum

Part A

Instruction Type	Absolute Value	Percentage
Instruction Count	1000000012	-
Loads	279866875	19.86%
Stores	129203343	9.17%
NOPs	0	0.00%
Direct Calls	556664	0.04%
Indirect Calls	0	0.00%
Returns	5556665	0.04%
Unconditional Branches	834555	0.06%
Conditional Branches	157417367	11.17%
Logical operations	146293204	10.38%
Rotate and Shift	107083358	7.60%
Flag Operations	0	0.00%
Vector Instructions	0	0.00%
Conditional Moves	0	0.00%
MMX and SSE instructions	0	0.00%
System Calls	0	0.00%
Floating Point Instructions	0	0.00%
The rest	587258199	41.68%

Part B

CPI: 21.03154

Part C

Data Chunk Accesses: 1048592
Instruction Chunk Accesses: 68

Part D

Distribution of Instruction Length

Bytes	Count
0	0
1	61187360
2	442809998
3	437560012
4	51733083
5	834758
6	1113146
7	4761655
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0

Distribution of the number of operands in an instruction

Operands	Count
0	0
1	0
2	467945159
3	476703754
4	54794435
5	556664
6	0
7	0
8	0
9	0

Distribution of the number of register read operands in an instruction

Reads	Count
0	0
1	314502858
2	461095420
3	223845200
4	556534
5	0
6	0
7	0
8	0
9	0

Distribution of the number of register write operands in an instruction

Writes	Count
0	101552907
1	655482274
2	242408553
3	556278
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory operands in an instruction

Operands	Count
0	616075341
1	358779120
2	25145551
3	0
4	0

Operands	Count
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory read operands in an instruction

Operands	Count
0	104057794
1	279866877
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory write operands in an instruction

Operands	Count
0	254721326
1	129203345
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Maximum number of bytes touched by an instruction: 4
Average number of bytes touched by an instruction: 3.60445
Maximum value of immediate: 124
Minimum value of immediate: -1
Maximum value of displacement used in memory addressing: 134982404
Minimum value of displacement used in memory addressing: -64

470.lbm

Part A

Instruction Type	Absolute Value	Percentage
Instruction Count	999999999	-
Loads	709947171	35.99%
Stores	262836303	13.32%
NOPs	14	0.00%
Direct Calls	163	0.00%
Indirect Calls	16	0.00%
Returns	179	0.00%
Unconditional Branches	4767427	0.24%
Conditional Branches	7791725	0.39%
Logical operations	5059493	0.26%
Rotate and Shift	196	0.00%
Flag Operations	79396	0.00%
Vector Instructions	0	0.00%
Conditional Moves	0	0.00%
MMX and SSE instructions	0	0.00%
System Calls	0	0.00%
Floating Point Instructions	965338837	48.93%
The rest	16962553	0.86%

Part B

CPI: 35.02404

Part C

Data Chunk Accesses: 13121299
Instruction Chunk Accesses: 381

Part D

Distribution of Instruction Length

Bytes	Count
0	0
1	106686
2	487544911
3	179628039
4	891
5	7579131
6	324469699
7	645484
8	0
9	0
10	25158
11	0
12	0
13	0
14	0
15	0

Distribution of the number of operands in an instruction

Operands	Count
0	14
1	19
2	13365172
3	457059385
4	529575202
5	179
6	28
7	0
8	0
9	0

Distribution of the number of register read operands in an instruction

Reads	Count
0	44824719
1	133972972
2	604379423
3	216822702
4	139
5	16
6	28
7	0
8	0
9	0

Distribution of the number of register write operands in an instruction

Writes	Count
0	131900105
1	822007170
2	46092569
3	155
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory operands in an instruction

Operands	Count
0	510666322
1	489308326
2	25351
3	0
4	0

Operands	Count
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory read operands in an instruction

Operands	Count
0	131821462
1	357512215
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory write operands in an instruction

Operands	Count
0	357486864
1	131846813
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Maximum number of bytes touched by an instruction: 8
Average number of bytes touched by an instruction: 7.95169
Maximum value of immediate: 2147483647
Minimum value of immediate: -1672357186
Maximum value of displacement used in memory addressing: 3216104
Minimum value of displacement used in memory addressing: -16080

482.sphinx3

Part A

Instruction Type	Absolute Value	Percentage
Instruction Count	999999997	-
Loads	441157275	29.21%
Stores	69242205	4.58%
NOPs	179676	0.01%
Direct Calls	3278122	0.22%
Indirect Calls	511	0.00%
Returns	3278634	0.22%
Unconditional Branches	5487101	0.36%
Conditional Branches	112770156	7.47%
Logical operations	35272619	2.34%
Rotate and Shift	264878	0.02%
Flag Operations	4318691	0.29%
Vector Instructions	0	0.00%
Conditional Moves	0	0.00%
MMX and SSE instructions	0	0.00%
System Calls	0	0.00%
Floating Point Instructions	412503500	27.31%
The rest	422646109	27.98%

Part B

CPI: 24.31672

Part C

Data Chunk Accesses: 154004
Instruction Chunk Accesses: 1173

Part D

Distribution of Instruction Length

Bytes	Count
0	0
1	81214950
2	430545481
3	432113066
4	26290007
5	7126668
6	17912431
7	4753425
8	43956
9	0
10	13
11	0
12	0
13	0
14	0
15	0

Distribution of the number of operands in an instruction

Operands	Count
0	179676
1	7759
2	301660182
3	502104074
4	179681579
5	16290903
6	75824
7	0
8	0
9	0

Distribution of the number of register read operands in an instruction

Reads	Count
0	5015943
1	112978870
2	585929061
3	151630334
4	131357184
5	13012781
6	75824
7	0
8	0
9	0

Distribution of the number of register write operands in an instruction

Writes	Count
0	45850688
1	833895779
2	120176297
3	77233
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory operands in an instruction

Operands	Count
0	50870569
1	480373250
2	10921050
3	0
4	0

Operands	Count
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory read operands in an instruction

Operands	Count
0	55474540
1	435819760
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Distribution of the number of memory write operands in an instruction

Operands	Count
0	424898710
1	66395590
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Maximum number of bytes touched by an instruction: 8 \ **Average number of bytes touched by an instruction:** 3.99254
Maximum value of immediate: 2147483647
Minimum value of immediate: -2147483648
Maximum value of displacement used in memory addressing: 135127364
Minimum value of displacement used in memory addressing: -121088