CS422 Assignment-1 Report

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This report consists analysis of the **SPEC 2006** benchmark applications using PIN tool. Basic block instrumentation is used for analysis of the applications. For each application 1 billion instructions are analysed after fast-forwarding them by a specified amount. Following benchmark applications are analysed:

- Perlbench
- BZip2
- GCC
- MCF
- Soplex
- Hmmer
- Omnetpp
- Xalancbmk
- CactusADM
- leslie3D
- libquantum
- LBM
- Sphinx3

PART A

This part presents classification of instructions on the basic of their type. Total instruction count of below tables may be greater than total instructions analysed i.e. 1 billion, because some load-store instructions with memory operand access more than 4 bytes are counted as combination of micro-instructions each with granularity of 4 bytes.

1.1 Perl benchmark

Fast-forward count = 207000000000
Instructions analysed = 1000000000

Type of instruction	No of instructions	Percentage
Load	356483738	22.8189
Store	205910029	13.1805
NOP	964138	0.0617156
Direct Call	12773812	0.817667
Indirect Call	2830877	0.181208
Return	15604690	0.998875
Uncond Branch	30535548	1.95462
Cond Branch	130024023	8.32299
Logical	100207368	6.41439
Rotate and Shift	4265819	0.27306
Flag	863995	0.0553053
Vector	0	0
CMOVE	0	0
MMX and SSE	0	0
Syscall	0	0
Floating Point	939494	0.0601381
Others	700823593	44.8605

1.2 BZip2 benchmark

Fast-forward count = 301000000000
Instructions analysed = 1000000007

Type of instruction	No of instructions	Percentage
Load	452706040	26.8848
Store	231174164	13.7287
NOP	36514	0.00216845
Direct Call	791594	0.0470102
Indirect Call	13	7.72028e-07
Return	791603	0.0470108
Uncond Branch	21299236	1.26489
Cond Branch	129923090	7.71572
Logical	71000790	4.21651
Rotate and Shift	61832039	3.67201
Flag	6130	0.000364041
Vector	0	0
CMOVE	0	0
MMX and SSE	0	0
Syscall	0	0
Floating Point	0	0
Others	714314913	42.4209

1.3 GCC benchmark

Fast-forward count = 107000000000
Instructions analysed = 1000000001

Type of instruction	No of instructions	Percentage
Load	139162863	9.29274
Store	358449892	23.9358
NOP	188348	0.0125771
Direct Call	4618998	0.308438
Indirect Call	501074	0.0334597
Return	5120074	0.341898
Uncond Branch	5050044	0.337222
Cond Branch	133649285	8.92456
Logical	131958986	8.81169
Rotate and Shift	2335333	0.155944
Flag	184823	0.0123417
Vector	0	0
CMOVE	0	0
MMX and SSE	0	0
Syscall	0	0
Floating Point	5	3.3388e-07
Others	716324625	47.8333

1.4 MCF benchmark

Fast-forward count = 377000000000
Instructions analysed = 1000000000

Type of instruction	No of instructions	Percentage
Load	415212729	27.2226
Store	110040144	7.21455
NOP	1477639	0.0968783
Direct Call	12556322	0.823229
Indirect Call	0	0
Return	12556322	0.823229
Uncond Branch	8314495	0.545122
Cond Branch	178242990	11.6861
Logical	75119509	4.92505
Rotate and Shift	3516414	0.230546
Flag	0	0
Vector	0	0
CMOVE	0	0
MMX and SSE	0	0
Syscall	0	0
Floating Point	0	0
Others	708216309	46.4327

1.5 Soplex benchmark

Fast-forward count = 364000000000
Instructions analysed = 999999988

Type of instruction	No of instructions	Percentage
Load	546362921	33.1629
Store	101149989	6.13956
NOP	11471	0.000696262
Direct Call	3199444	0.194198
Indirect Call	135	8.19417e-06
Return	3199579	0.194207
Uncond Branch	13171098	0.799453
Cond Branch	103110465	6.25855
Logical	13848285	0.840557
Rotate and Shift	10323886	0.626635
Flag	23244985	1.41091
Vector	0	0
CMOVE	0	0
MMX and SSE	0	0
Syscall	0	0
Floating Point	306667412	18.614
Others	523223228	31.7584

1.6 Hmmer benchmark

Fast-forward count = 264000000000
Instructions analysed = 1000000002

Type of instruction	No of instructions	Percentage
Load	547670762	33.7367
Store	75698745	4.66307
NOP	34317	0.00211394
Direct Call	144622	0.00890876
Indirect Call	959	5.90747e-05
Return	145581	0.00896783
Uncond Branch	205862	0.0126812
Cond Branch	144361425	8.89271
Logical	1158703	0.0713765
Rotate and Shift	294106	0.018117
Flag	5669	0.000349212
Vector	0	0
CMOVE	0	0
MMX and SSE	0	0
Syscall	0	0
Floating Point	40212	0.00247707
Others	853607583	52.5825

1.7 Omnetpp benchmark

Fast-forward count = 43000000000
Instructions analysed = 1000000006

Type of instruction	No of instructions	Percentage
Load	371235126	23.1873
Store	229791046	14.3527
NOP	802403	0.050118
Direct Call	21327720	1.33213
Indirect Call	3689256	0.230431
Return	25016977	1.56256
Uncond Branch	22189673	1.38597
Cond Branch	117335261	7.32875
Logical	60009439	3.74819
Rotate and Shift	7139688	0.445944
Flag	20159883	1.25919
Vector	0	0
CMOVE	0	0
MMX and SSE	0	0
Syscall	0	0
Floating Point	96963597	6.05634
Others	625366109	39.0603

1.8 Xalancbmk benchmark

Fast-forward count = 1331000000000
Instructions analysed = 1000000007

Type of instruction	No of instructions	Percentage
Load	367495914	23.8832
Store	171714512	11.1595
NOP	21365212	1.3885
Direct Call	13608951	0.884432
Indirect Call	9002333	0.585052
Return	22614901	1.46972
Uncond Branch	8864823	0.576116
Cond Branch	174995540	11.3728
Logical	38095167	2.47577
Rotate and Shift	5775849	0.375366
Flag	1712287	0.11128
Vector	0	0
CMOVE	0	0
MMX and SSE	0	0
Syscall	0	0
Floating Point	7473263	0.48568
Others	696003999	45.2326

1.9 CactusADM benchmark

Fast-forward count = 584000000000
Instructions analysed = 999999955

Type of instruction	No of instructions	Percentage
Load	1040896860	43.8792451
Store	331288160	13.9655
NOP	2265	9.54816e-05
Direct Call	531584	0.022409
Indirect Call	193	8.13596e-06
Return	531777	0.0224172
Uncond Branch	535271	0.0225645
Cond Branch	4305620	0.181504
Logical	1626453	0.0685635
Rotate and Shift	1059310	0.0446555
Flag	5	2.10776e-07
Vector	0	0
CMOVE	0	0
MMX and SSE	0	0
Syscall	0	0
Floating Point	851723464	35.9046
Others	139684013	5.88841

1.10 leslie3D benchmark

Fast-forward count = 2346000000000
Instructions analysed = 1000000044

Type of instruction	No of instructions	Percentage
Load	736426855	38.0104
Store	201007956	10.375
NOP	83321	0.00430058
Direct Call	913	4.71242e-05
Indirect Call	17	8.77449e-07
Return	930	4.80016e-05
Uncond Branch	169181	0.00873222
Cond Branch	41549505	2.14456
Logical	435798	0.0224936
Rotate and Shift	5168220	0.266756
Flag	32	1.65167e-06
Vector	0	0
CMOVE	0	0
MMX and SSE	0	0
Syscall	0	0
Floating Point	394808591	20.3779
Others	557783534	28.7898

1.11 libquantum benchmark

Fast-forward count = 3605000000000
Instructions analysed = 1000000001

Type of instruction	No of instructions	Percentage
Load	279866814	19.8618
Store	129203276	9.1694
NOP	0	0
Direct Call	556654	0.0395051
Indirect Call	0	0
Return	556656	0.0395052
Uncond Branch	834543	0.0592265
Cond Branch	157417491	11.1717
Logical	146293146	10.3822
Rotate and Shift	107083385	7.59958
Flag	0	0
Vector	0	0
CMOVE	0	0
MMX and SSE	0	0
Syscall	0	0
Floating Point	0	0
Others	587258126	41.677

1.12 lbm benchmark

Fast-forward count = 830000000000
Instructions analysed = 999999985

Type of instruction	No of instructions	Percentage
Load	709947335	35.9871
Store	262836273	13.3231
NOP	14	7.09657e-07
Direct Call	163	8.26244e-06
Indirect Call	16	8.11037e-07
Return	179	9.07347e-06
Uncond Branch	4767438	0.24166
Cond Branch	7791772	0.394963
Logical	5059503	0.256465
Rotate and Shift	196	9.9352e-06
Flag	79428	0.00402619
Vector	0	0
CMOVE	0	0
MMX and SSE	0	0
Syscall	0	0
Floating Point	965338685	48.9328
Others	16962591	0.85983

1.13 Sphinx3 benchmark

Fast-forward count = 1513000000000
Instructions analysed = 1000000001

Type of instruction	No of instructions	Percentage
Load	441157129	29.208
Store	69242029	4.58435
NOP	179673	0.0118957
Direct Call	3278114	0.217036
Indirect Call	511	3.38321e-05
Return	3278626	0.21707
Uncond Branch	5487117	0.363289
Cond Branch	112770161	7.46625
Logical	35272617	2.33532
Rotate and Shift	264878	0.017537
Flag	4318701	0.285931
Vector	0	0
CMOVE	0	0
MMX and SSE	0	0
Syscall	0	0
Floating Point	412503623	27.3109
Others	422645830	27.9824

PART B

This part contains the approximated CPI for each application. Load and store instructions are assigned a latency of 50 cycles and other instructions a latency of 1 cycle. Each memory access in load-store instructions which accesses more than 4 bytes, is treated as a combination of micro-instructions each with maximum granularity of 4 bytes. Every such micro-instruction is also assigned a latency of 50 cycles. CPI is calculated as:

$$CPI = \frac{Total\ latency}{Total\ instructions\ executed}$$

The denominator used while calculating CPI is the total number of instructions analysed i.e. 1 billion instructions

Benchmark Application	CPI
Perl	29.1195
Bzip2	35.194
GCC	25.8806
MCF	27.2626
Soplex	33.3756
Hmmer	32.1685
Omnetpp	31.0513
Xalancbmk	27.96
cactusADM	69.6093
leslie3D	47.8717
libquantum	21.4535
lbm	49.6392
Sphinx3	26.52

PART C

This part contains the instruction and data footprint of each application. The values shown are the number of 32 bytes chunks accessed.

Benchmark Application	Instruction Footprint	Data Footprint
Perl	2833	31192
Bzip2	759	2537194
GCC	2972	1146580
MCF	65	11672867
Soplex	1180	5694980
Hmmer	488	84066
Omnetpp	901	554205
Xalancbmk	2313	684728
cactusADM	1227	4388946
leslie3D	2640	2483519
libquantum	68	1048594
lbm	381	13161100
Sphinx3	1178	155091

PART D

Distribution of instruction length

Lenght →	1	2	3	4	5	6	7	8	9	10
Perl	117438301	256746712	274820857	52916782	78558007	185550377	33968924	28	0	12
Bzip2	38611284	219201492	436965826	75326947	22047390	141357199	51341627	15085632	0	62610
GCC	129693440	590854867	125452637	115667817	11473135	15973477	10826384	58244	0	0
MCF	80626407	485393417	315526414	50531242	22076579	5249816	40596125	0	0	0
Soplex	77075395	441684229	398958209	16506344	3277725	40943865	17615559	3938662	0	0
Hmmer	25078459	302860552	296150909	270388803	24861234	68360210	416480	11883355	0	0
Omnetpp	154578785	308551294	382074568	34347863	45117265	48822849	26506961	0	0	421
Xalancbmk	146307029	318001304	445795819	32640898	24680308	24259604	7907558	270976	64932	71579
cactusADM	1658078	263441929	78112053	15678310	1609528	603728318	35771739	0	0	0
leslie3D	34716453	503707845	58912498	82555	412266	400346631	1821778	0	0	18
libquantum	61187279	442810138	437559940	51733122	834744	1113128	4761650	0	0	0
lbm	106726	487544737	179628268	891	7579139	324469574	645484	0	0	25166
Sphinx3	81214919	430545540	432113062	26290000	7126655	17912434	4753422	43956	0	13

Distribution of no of operands in an instruction

No of operand →	0	1	2	3	4	5	6
Perl	964138	1072837	520635724	355139937	103311509	15606362	3269493
Bzip2	36514	6147	597647547	382870362	2693836	14191393	2554208
GCC	188348	4598131	350004286	403953769	33905153	203095031	4255283
MCF	1477639	0	484784781	457347030	43834228	12556322	0
Soplex	11471	23	415270464	395014083	186468150	3235797	0
Hmmer	34887	3512	566126764	432938365	713115	159551	23808
Omnetpp	802403	225879	518294390	281743933	172763919	25030567	1138915
Xalancbmk	21365212	764448	426615380	407753198	104172637	24621715	14707417
cactusADM	2265	23	83585153	461382384	454498323	531777	30
leslie3D	83321	33	317860127	492868731	189186796	992	44
libquantum	0	0	467945199	476703720	54794428	556654	0
lbm	14	19	13365270	457059405	529575070	179	28
Sphinx3	179673	7759	301660133	502104152	179681565	16290895	75824

Distribution of no of register read operands in an instruction

Reg read op →	0	1	2	3	4	5	6
Perl	10120999	260213938	537592761	179147969	7066181	2588659	3269493
Bzip2	5189068	183351742	533608234	215105813	46791143	13399799	2554208
GCC	2134142	169148217	472914470	62942730	90130524	198474635	4255283
MCF	3759879	148510531	677530705	170198885	0	0	0
Soplex	23455378	216024875	577322214	140222809	42938380	36332	0
Hmmer	610947	75620185	562398803	281425785	79905545	14929	23808
Omnetpp	29000210	197518861	540431958	219765948	8457505	3686609	1138915
Xalancbmk	28914756	235520711	460266460	250458592	1253011	8879060	14707417
cactusADM	18274791	42914500	532137853	397790765	8881881	135	30
leslie3D	357050	58705744	653894608	270600840	16441686	72	44
libquantum	0	314502974	461095281	223845222	556524	0	0
lbm	44824694	133972921	604379384	216822803	139	16	28
Sphinx3	5015950	112978727	585929235	151630399	131357085	13012781	75824

Distribution of no of register write operands in an instruction

Reg write op →	0	1	2	3	4
Perl	135861745	685065114	175800056	2390781	882304
Bzip2	132331464	712782338	152331980	2554225	0
GCC	125591483	420003353	450007806	4397359	0
MCF	70906582	770283685	158771221	38512	0
Soplex	69539601	764796453	165663934	0	0
Hmmer	75149177	755280001	169547016	23808	0
Omnetpp	165349957	665542468	167592652	376014	1138915
Xalancbmk	114922523	683332055	187036047	14709382	0
cactusADM	149849527	791740333	58409939	126	30
leslie3D	68909590	735960213	195130083	158	0
libquantum	101552950	655482364	242408417	556270	0
lbm	131900118	822007100	46092612	155	0
Sphinx3	45850689	833895826	120176253	77233	0

Distribution of no of memory operands in an instruction

No of memory op →	0	1	2
Perl	453525927	530767788	15539642
Bzip2	399852577	516406486	83736859
GCC	518722395	464805648	16403552
MCF	487182309	500382509	12435182
Soplex	530021437	439601902	30376649
Hmmer	376808160	623024770	166109
Omnetpp	449250180	542984705	7765121
Xalancbmk	490212169	482949048	26351108
cactusADM	273540954	690600284	35858717
leslie3D	378021458	548828723	73149861
libquantum	616075394	358779124	25145483
lbm	510666254	489308372	25359
Sphinx3	508705595	480373177	10921079

Distribution of no of memory read operands in an instruction

No of memory read op →	0	1	2
Perl	644308863	354642213	882281
Bzip2	547289882	452706040	0
GCC	860768735	139162860	0
MCF	584787271	415212729	0
Soplex	582900704	417099284	0
Hmmer	452336160	547662879	0
Omnetpp	661700933	337160158	1138915
Xalancbmk	634408460	365103865	0
cactusADM	424465532	575534393	30
leslie3D	446851007	553149035	0
libquantum	720133187	279866814	0
lbm	642487696	357512289	0
Sphinx3	564180084	435819767	0

Distribution of no of memory write operands in an instruction

Mem write op →	0	1
Perl	794393060	205440297
Bzip2	768821758	231174164
GCC	641481703	358449892
MCF	889959856	110040144
Soplex	916744072	83255916
Hmmer	924304930	75694109
Omnetpp	780923047	219076959
Xalancbmk	828964926	170547399
cactusADM	813216690	186783265
leslie3D	858020632	141979410
libquantum	870796725	129203276
lbm	868153184	131846801
Sphinx3	933604283	66395568

Bytes Touched

	Maximum	Average
Perl	8	3.73839
Bzip2	4	3.48541
GCC	8	3.95806
MCF	4	4
Soplex	8	5.25245
Hmmer	8	3.99751
Omnetpp	8	4.22175
Xalancbmk	8	4.15018
cactusADM	8	7.35779
leslie3D	10	5.55829
libquantum	4	3.60445
lbm	8	7.95169
Sphinx3	8	3.99254

Immediate Fields

	Max	Min
Perl	2147483647	-2147483648
Bzip2	1431655766	-858993459
GCC	1073741823	-2147483587
MCF	1374389535	-100000000
Soplex	2147483647	-1074790400
Hmmer	2147483647	-987654321
Omnetpp	2147483647	-2092037281
Xalancbmk	2147483647	-1431655765
cactusADM	1431655766	-2147483648
leslie3D	2147483647	-2147483648
libquantum	124	-1
lbm	2147483647	-1672357186
Sphinx3	2147483647	-2147483648

Displacement Fields

	Max	Min
Perl	135918104	-1408
Bzip2	135000192	-4848
GCC	138634432	-1744
MCF	134957120	-76
Soplex	135856732	-344
Hmmer	135294312	-580
Omnetpp	136090116	-104
Xalancbmk	139657912	-1392
cactusADM	135701372	-2620
leslie3D	135182404	-1760
libquantum	134982404	-64
lbm	3216104	-16080
Sphinx3	135127364	-121088

Some other details

Benchmark Application	Max BBL Size	Min BBL Size	Avg BBL Size
Perl	53	1	5.10455
Bzip2	54	1	5.92538
GCC	40	1	2.84557
MCF	29	1	4.72433
Soplex	70	1	8.14854
Hmmer	68	1	6.90133
Omnetpp	33	1	5.23782
Xalancbmk	59	1	4.08883
cactusADM	70	1	51.1664
leslie3D	70	1	22.1727
libquantum	28	1	6.27489
lbm	70	1	45.3286
Sphinx3	56	1	7.25107