

# CERN openlab II

CPU-level

Performance Monitoring  
with perfmon/pfmon



Andreas Hirstius  
Andreas.Hirstius at cern.ch

## perfmon

- A powerful interface to the Performance Monitoring Units (PMUs) in the processor(s)
  - Very detailed information available
    - ~140 events / 5 counters available on Core2 based CPUs
    - ~120 events / 4 counters available on AMDs Barcelona
    - ~650 events / 12 counters available on Montecito (Itanium2)
    - ... the Cray X2 provides ~2000 events ...
  - Very little/no overhead for non-latency bound applications
  - Allows for counting or sampling (== non-intrusive profiling)
  - More info:
    - <http://perfmon2.sourceforge.net>
    - Overview: <http://perfmon2.sourceforge.net/perfmon2-20080124.pdf>

## pfmon

- Allows for multiplexing – measuring a large number of performance counter events by switching between different sets – a large number of events can be measured at the same time if the application runs long enough
- Improvements submitted by Andrzej Nowak include
  - Proper correlation of symbols across `dlopen()/dlclose()` calls
  - Rewrite of symbol table parsing and management
  - And others ...
- Many more improvements ...
- ➔ Pfmon is now in a state that it can be used on HEP/CERN software ... we have a huge number of shared libs !!

- In connection with the HEPiX benchmark WG
- Running on 3GHz Woodcrests (Xeon 5160)
- Getting CPU level performance information for
  - SPEC2000
    - int and fp benchmarks together
    - All sub-benchmarks separately
  - SPEC2006
    - int and fp benchmarks together
    - All sub-benchmarks separately
    - All C++ sub-benchmarks together
- In 32bit and 64bit mode (with CERN/HEP settings)
- Running as single job and with 4 parallel jobs (# of cores)

- Monitoring the jobs running on Ixbatch
  - Pfmon running in system-wide mode
  - overview over the application-mix on batch/worker nodes
  - “public” Ixbatch nodes used (ATLAS/CMS a bit underrepresented)
  - Kernel and additional packages have to be “production ready” !!
    - Previous attempt for low level monitoring using “perfctr” resulted in very unstable machines ...
    - The kernel with perfmon patches has to be stable
    - Running pfmon should not introduce instabilities
    - openafs had to rebuild for the new kernel
    - Up to now no instabilities :-)

- Comparing the SPEC performance with and without pfmon

Test	SPECInt2006	SPECfp2006
std. SLC4.6 w/ std. Kernel	34.26	25.6
std. SLC4.6 w/ 2.6.24.2 Kernel & perfmon patches & pfmon <i>inactive</i>	38.16 (111%)	27.77 (108%)
std. SLC4.6 w/ 2.6.24.2 Kernel & perfmon patches & pfmon <i>active</i>	38.23 (112%)	27.78 (108%)

- The performance “impact” of pfmon is
  - ➔ The performance actually **increases** !!!
    - ... mainly due to the newer kernel ...
- Measurements by Alejandro Iribarren

- CPI (Cycles per instruction)
- Load / Store instructions
- x87 instructions
- computational SIMD instructions
- Branch instructions
- Mispredicted branches
- Level2 cache misses (rate)
- Bus utilisation
- Data bus utilisation
- “Bus Not Ready”
- Resource stalls
- Detailed look into the resource stalls:
  - ROB full (Re-Order Buffer full)
  - RS full (Reservation Station full)
  - LD / ST limits
  - Mispredicted branches
  - FP ctrl word

# What do we measure – some details

- x87 and computational SIMD instructions
  - They are the “floating point” (FP) instructions
  - x87 instr. are default in 32bit mode
  - SIMD instr. are default in 64bit mode
- Mispredicted branches
  - Percentage of branches that were mispredicted
  - They carry a performance penalty (~14 cycles)!
- Level2 cache misses (rate)
  - Percentage of requests to the L2 cache that have to go to main memory
  - They carry a significant performance penalty (~250 cycles)!!!



- **Bus utilisation**
  - Percentage of bus cycles used to transfer bus transactions of any kind
- **Data bus utilisation**
  - Percentage of bus cycles used to transfer data
- **Bus Not Ready**
  - Percentage of bus cycles during which no new bus transactions can start.
  - A high value indicates a highly loaded and frequently overloaded/congested bus

- SPECint2000 contains ~1% floating point!!
- Only slightly faster in 64bit mode
  - Due to a few sub-benchmarks being extremely slowed down in 64bit mode!!
  - Significantly more L2 cache misses in 64bit mode
  - Slightly more mispredicted branches
  - BNR much higher in 64bit mode
  - Slightly more resource stalls in 64bit mode
  - ... but still significantly fewer actual instructions used !!

SPECint2000 – 32bit mode – 4 jobs		SPECint2000 – 64bit mode – 4 jobs	
45201237332100	UNHALTED_CORE_CYCLES	44804927344019	UNHALTED_CORE_CYCLES
45837316931397	INSTRUCTIONS_RETIRED	37967583644997	INSTRUCTIONS_RETIRED
7497308624143	BRANCH_INSTRUCTIONS_RETIRED	6421199461762	BRANCH_INSTRUCTIONS_RETIRED
302799323740	MISPREDICTED_BRANCH_RETIRED	288149260964	MISPREDICTED_BRANCH_RETIRED
19296716652582	INST_RETIRED:LOADS	12159284443871	INST_RETIRED:LOADS
624928	SIMD_COMP_INST_RETIRED:PACKED_SINGLE :SCALAR_SINGLE:PACKED_DOUBLE:SCALAR_DOUBLE	413103994039	SIMD_COMP_INST_RETIRED:PACKED_SINGLE :SCALAR_SINGLE:PACKED_DOUBLE:SCALAR_DOUBLE
9323887361488	INST_RETIRED:STORES	5366523996464	INST_RETIRED:STORES
442567549137	X87_OPS_RETIRED:ANY	57678491535	X87_OPS_RETIRED:ANY
22143424590558	RESOURCE_STALLS:ANY	23933277888657	RESOURCE_STALLS:ANY
378414578559	BUS_TRANS_ANY:ALL_AGENTS	724554943704	BUS_TRANS_ANY:ALL_AGENTS
308895207467	BUS_DRDY_CLOCKS:ALL_AGENTS	574793437730	BUS_DRDY_CLOCKS:ALL_AGENTS
1741997649	BUS_BNR_DRV:ALL_AGENTS	7859133902	BUS_BNR_DRV:ALL_AGENTS
543636967874	LAST_LEVEL_CACHE_REFERENCES	618095730129	LAST_LEVEL_CACHE_REFERENCES
27980144496	LAST_LEVEL_CACHE_MISSES	54049684697	LAST_LEVEL_CACHE_MISSES
5035359994977	CPU_CLK_UNHALTED:BUS	4992386647432	CPU_CLK_UNHALTED:BUS
-----		-----	
Ratios:		Ratios:	
	CPI: 0.9861		CPI: 1.1801
	load instructions %: 42.098%		load instructions %: 32.025%
	store instructions %: 20.341%		store instructions %: 14.134%
	load and store instructions %: 62.440%		load and store instructions %: 46.160%
	resource stalls % (of cycles): 48.989%		resource stalls % (of cycles): 53.417%
	branch instructions %: 16.356%		branch instructions %: 16.912%
	% of branch instr. mispredicted: 4.039%		% of branch instr. mispredicted: 4.487%
	% of 12 loads missed: 5.147%		% of 12 loads missed: 8.745%
	bus utilization %: 15.030%		bus utilization %: 29.026%
	data bus utilization %: 6.135%		data bus utilization %: 11.513%
	bus not ready %: 0.069%		bus not ready %: 0.315%
	comp. SIMD inst. ('new FP') %: 0.000%		comp. SIMD inst. ('new FP') %: 1.088%
	comp. x87 instr. ('old FP') %: 0.966%		comp. x87 instr. ('old FP') %: 0.152%

- SPECint2006 contains ~0.1% floating point ... negligible ...
- Only slightly faster in 64bit mode
  - Due to a few sub-benchmarks being extremely slowed down in 64bit mode!!
  - Slightly more L2 cache misses in 64bit mode, but very high miss rate in general
  - BNR much higher in 64bit mode
  - Slightly more resource stalls in 64bit mode
  - ... again, significantly fewer actual instructions in 64bit mode

SPECint2006 – 32bit mode – 4 jobs		SPECint2006 – 64bit mode – 4 jobs	
461179857748960	UNHALTED_CORE_CYCLES	453153422688509	UNHALTED_CORE_CYCLES
350589714455709	INSTRUCTIONS_RETIRED	303883044666778	INSTRUCTIONS_RETIRED
54906528688928	BRANCH_INSTRUCTIONS_RETIRED	48233916086552	BRANCH_INSTRUCTIONS_RETIRED
2903104696534	MISPREDICTED_BRANCH_RETIRED	2568377286745	MISPREDICTED_BRANCH_RETIRED
162881915117934	INST_RETIRED:LOADS	96299115605813	INST_RETIRED:LOADS
0	SIMD_COMP_INST_RETIRED:PACKED_SINGLE	359749309739	SIMD_COMP_INST_RETIRED:PACKED_SINGLE
	:SCALAR_SINGLE:PACKED_DOUBLE:SCALAR_DOUBLE		:SCALAR_SINGLE:PACKED_DOUBLE:SCALAR_DOUBLE
58657311592597	INST_RETIRED:STORES	33169229301278	INST_RETIRED:STORES
399618515172	X87_OPS_RETIRED:ANY	132684652120	X87_OPS_RETIRED:ANY
265980169455834	RESOURCE_STALLS:ANY	283825996907464	RESOURCE_STALLS:ANY
9030113964523	BUS_TRANS_ANY:ALL_AGENTS	11197303950198	BUS_TRANS_ANY:ALL_AGENTS
7313830415240	BUS_DRDY_CLOCKS:ALL_AGENTS	9007337650460	BUS_DRDY_CLOCKS:ALL_AGENTS
82885334380	BUS_BNR_DRV:ALL_AGENTS	226487203141	BUS_BNR_DRV:ALL_AGENTS
3945120792043	LAST_LEVEL_CACHE_REFERENCES	4818080605870	LAST_LEVEL_CACHE_REFERENCES
478431290431	LAST_LEVEL_CACHE_MISSES	720453702717	LAST_LEVEL_CACHE_MISSES
51581290410280	CPU_CLK_UNHALTED:BUS	50797500445973	CPU_CLK_UNHALTED:BUS
-----		-----	
Ratios:		Ratios:	
	CPI: 1.3154		CPI: 1.4912
	load instructions %: 46.459%		load instructions %: 31.690%
	store instructions %: 16.731%		store instructions %: 10.915%
	load and store instructions %: 63.190%		load and store instructions %: 42.605%
	resource stalls % (of cycles): 57.674%		resource stalls % (of cycles): 62.634%
	branch instructions %: 15.661%		branch instructions %: 15.873%
	% of branch instr. mispredicted: 5.287%		% of branch instr. mispredicted: 5.325%
	% of 12 loads missed: 12.127%		% of 12 loads missed: 14.953%
	bus utilization %: 35.013%		bus utilization %: 44.086%
	data bus utilization %: 14.179%		data bus utilization %: 17.732%
	bus not ready %: 0.321%		bus not ready %: 0.892%
	comp. SIMD inst. ('new FP') %: 0.000%		comp. SIMD inst. ('new FP') %: 0.118%
	comp. x87 instr. ('old FP') %: 0.114%		comp. x87 instr. ('old FP') %: 0.044%

- The SPEC2006 C++ benchmarks contain 10-14% floating point
- **Slower** in 64bit mode !!
  - Almost all C++ benchmarks are slowed down in 64bit mode!!
  - Slightly more L2 cache misses in 64bit mode, but very high miss rate in general
  - Slightly more mispredicted branches in 64bit mode
  - BNR higher in 64bit mode
  - ~10% more resource stalls in 64bit mode
  - ... again, fewer actual instructions in 64bit mode

SPEC2006 C++ – 32bit mode – 4 jobs		SPEC2006 C++ – 64bit mode – 4 jobs	
196604109151652	UNHALTED_CORE_CYCLES	215947712982588	UNHALTED_CORE_CYCLES
150762226596169	INSTRUCTIONS_RETIRED	119991871388997	INSTRUCTIONS_RETIRED
20597482426950	BRANCH_INSTRUCTIONS_RETIRED	18241941807980	BRANCH_INSTRUCTIONS_RETIRED
764119332313	MISPREDICTED_BRANCH_RETIRED	745321349045	MISPREDICTED_BRANCH_RETIRED
59343184864687	INST_RETIRED:LOADS	36586210736816	INST_RETIRED:LOADS
0	SIMD_COMP_INST_RETIRED:PACKED_SINGLE	16549768252572	SIMD_COMP_INST_RETIRED:PACKED_SINGLE
	:SCALAR_SINGLE:PACKED_DOUBLE:SCALAR_DOUBLE		:SCALAR_SINGLE:PACKED_DOUBLE:SCALAR_DOUBLE
22653050918291	INST_RETIRED:STORES	11817242786897	INST_RETIRED:STORES
16499979718174	X87_OPS_RETIRED:ANY	17200520909	X87_OPS_RETIRED:ANY
121652777590140	RESOURCE_STALLS:ANY	150950098548670	RESOURCE_STALLS:ANY
4058630608266	BUS_TRANS_ANY:ALL_AGENTS	5005296800109	BUS_TRANS_ANY:ALL_AGENTS
3131296782062	BUS_DRDY_CLOCKS:ALL_AGENTS	3821979997184	BUS_DRDY_CLOCKS:ALL_AGENTS
30656103004	BUS_BNR_DRV:ALL_AGENTS	47675704094	BUS_BNR_DRV:ALL_AGENTS
2216257328615	LAST_LEVEL_CACHE_REFERENCES	2767263319645	LAST_LEVEL_CACHE_REFERENCES
307891738955	LAST_LEVEL_CACHE_MISSES	410542553241	LAST_LEVEL_CACHE_MISSES
22121483842719	CPU_CLK_UNHALTED:BUS	24255546086757	CPU_CLK_UNHALTED:BUS
-----		-----	
Ratios:		Ratios:	
	CPI: 1.3041		CPI: 1.7997
	load instructions %: 39.362%		load instructions %: 30.491%
	store instructions %: 15.026%		store instructions %: 9.848%
	load and store instructions %: 54.388%		load and store instructions %: 40.339%
	resource stalls % (of cycles): 61.877%		resource stalls % (of cycles): 69.901%
	branch instructions %: 13.662%		branch instructions %: 15.203%
	% of branch instr. mispredicted: 3.710%		% of branch instr. mispredicted: 4.086%
	% of 12 loads missed: 13.892%		% of 12 loads missed: 14.836%
	bus utilization %: 36.694%		bus utilization %: 41.271%
	data bus utilization %: 14.155%		data bus utilization %: 15.757%
	bus not ready %: 0.277%		bus not ready %: 0.393%
	comp. SIMD inst. ('new FP') %: 0.000%		comp. SIMD inst. ('new FP') %: 13.792%
	comp. x87 instr. ('old FP') %: 10.944%		comp. x87 instr. ('old FP') %: 0.014%

- A BAD example
- Much slower in 64bit mode
  - Using MORE instructions in 64bit mode
  - Much higher L2 cache miss rate in 64bit mode
- More branches in 64bit mode
- Significantly more mispredicted branches in 64bit mode
- BNR and bus utilisation actually lower in 64bit mode

SPEC2006 410.bwaves – 32bit mode – 4 jobs		SPEC2006 410.bwaves – 64bit mode – 4 jobs	
66184607716621	UNHALTED_CORE_CYCLES	82646441371942	UNHALTED_CORE_CYCLES
32038993376478	INSTRUCTIONS_RETIRED	43269747823376	INSTRUCTIONS_RETIRED
1045662341511	BRANCH_INSTRUCTIONS_RETIRED	3377043818102	BRANCH_INSTRUCTIONS_RETIRED
5569854319	MISPREDICTED_BRANCH_RETIRED	146650527607	MISPREDICTED_BRANCH_RETIRED
19500786788306	INST_RETIRED:LOADS	14517944486917	INST_RETIRED:LOADS
0	SIMD_COMP_INST_RETIRED:PACKED_SINGLE :SCALAR_SINGLE:PACKED_DOUBLE:SCALAR_DOUBLE	10476785264283	SIMD_COMP_INST_RETIRED:PACKED_SINGLE :SCALAR_SINGLE:PACKED_DOUBLE:SCALAR_DOUBLE
4768056184869	INST_RETIRED:STORES	2998919112401	INST_RETIRED:STORES
6752053870705	X87_OPS_RETIRED:ANY	10959281897	X87_OPS_RETIRED:ANY
55650366867224	RESOURCE_STALLS:ANY	62157492993642	RESOURCE_STALLS:ANY
2795205261519	BUS_TRANS_ANY:ALL_AGENTS	2794173784751	BUS_TRANS_ANY:ALL_AGENTS
1975145132590	BUS_DRDY_CLOCKS:ALL_AGENTS	1974651943707	BUS_DRDY_CLOCKS:ALL_AGENTS
36173999054	BUS_BNR_DRV:ALL_AGENTS	35367284875	BUS_BNR_DRV:ALL_AGENTS
580148778988	LAST_LEVEL_CACHE_REFERENCES	550307895671	LAST_LEVEL_CACHE_REFERENCES
81972164145	LAST_LEVEL_CACHE_MISSES	112587229075	LAST_LEVEL_CACHE_MISSES
7369433865245	CPU_CLK_UNHALTED:BUS	9209403050219	CPU_CLK_UNHALTED:BUS
-----		-----	
Ratios:		Ratios:	
	CPI: 2.0658		CPI: 1.9100
	load instructions %: 60.866%		load instructions %: 33.552%
	store instructions %: 14.882%		store instructions %: 6.931%
	load and store instructions %: 75.748%		load and store instructions %: 40.483%
	resource stalls % (of cycles): 84.084%		resource stalls % (of cycles): 75.209%
	branch instructions %: 3.264%		branch instructions %: 7.805%
	% of branch instr. mispredicted: 0.533%		% of branch instr. mispredicted: 4.343%
	% of 12 loads missed: 14.130%		% of 12 loads missed: 20.459%
	bus utilization %: 75.859%		bus utilization %: 60.681%
	data bus utilization %: 26.802%		data bus utilization %: 21.442%
	bus not ready %: 0.982%		bus not ready %: 0.768%
	comp. SIMD inst. ('new FP') %: 0.000%		comp. SIMD inst. ('new FP') %: 24.213%
	comp. x87 instr. ('old FP') %: 21.074%		comp. x87 instr. ('old FP') %: 0.025%



# Pfmon – SPEC2006 example II

- A really GOOD example
- Much faster in 64bit mode
  - ~46% fewer “core cycles” !!!
  - Only ~12% fewer instructions

SPEC2006 435.gromacs – 32bit mode – 4 jobs		SPEC2006 435.gromacs – 64bit mode – 4 jobs	
52545097029601	UNHALTED_CORE_CYCLES	28335415184402	UNHALTED_CORE_CYCLES
28239032175254	INSTRUCTIONS_RETIRED	24923444284898	INSTRUCTIONS_RETIRED
786718407198	BRANCH_INSTRUCTIONS_RETIRED	755991835848	BRANCH_INSTRUCTIONS_RETIRED
49833012629	MISPREDICTED_BRANCH_RETIRED	48309357560	MISPREDICTED_BRANCH_RETIRED
11318465152987	INST_RETIRED:LOADS	8722788997385	INST_RETIRED:LOADS
0	SIMD_COMP_INST_RETIRED:PACKED_SINGLE	9695772998672	SIMD_COMP_INST_RETIRED:PACKED_SINGLE
	:SCALAR_SINGLE:PACKED_DOUBLE:SCALAR_DOUBLE		:SCALAR_SINGLE:PACKED_DOUBLE:SCALAR_DOUBLE
5018510676257	INST_RETIRED:STORES	3515929682894	INST_RETIRED:STORES
9717550976444	X87_OPS_RETIRED:ANY	1692222816	X87_OPS_RETIRED:ANY
41735531957443	RESOURCE_STALLS:ANY	18613627304402	RESOURCE_STALLS:ANY
74104263298	BUS_TRANS_ANY:ALL_AGENTS	76000740916	BUS_TRANS_ANY:ALL_AGENTS
59386726849	BUS_DRDY_CLOCKS:ALL_AGENTS	61365932872	BUS_DRDY_CLOCKS:ALL_AGENTS
15596654	BUS_BNR_DRV:ALL_AGENTS	32145113	BUS_BNR_DRV:ALL_AGENTS
224259236583	LAST_LEVEL_CACHE_REFERENCES	227650501186	LAST_LEVEL_CACHE_REFERENCES
3380348570	LAST_LEVEL_CACHE_MISSES	3661361080	LAST_LEVEL_CACHE_MISSES
5842738075086	CPU_CLK_UNHALTED:BUS	3152227191304	CPU_CLK_UNHALTED:BUS
-----		-----	
Ratios:		Ratios:	
	CPI: 1.8607		CPI: 1.1369
	load instructions %: 40.081%		load instructions %: 34.998%
	store instructions %: 17.772%		store instructions %: 14.107%
	load and store instructions %: 57.852%		load and store instructions %: 49.105%
	resource stalls % (of cycles): 79.428%		resource stalls % (of cycles): 65.690%
	branch instructions %: 2.786%		branch instructions %: 3.033%
	% of branch instr. mispredicted: 6.334%		% of branch instr. mispredicted: 6.390%
	% of 12 loads missed: 1.507%		% of 12 loads missed: 1.608%
	bus utilization %: 2.537%		bus utilization %: 4.822%
	data bus utilization %: 1.016%		data bus utilization %: 1.947%
	bus not ready %: 0.001%		bus not ready %: 0.002%
	comp. SIMD inst. ('new FP') %: 0.000%		comp. SIMD inst. ('new FP') %: 38.902%
	comp. x87 instr. ('old FP') %: 34.412%		comp. x87 instr. ('old FP') %: 0.001%

- Pfmon in system-wide mode
  - Running on five batch nodes for one month
  - All “inefficiencies” like waiting for CASTOR are included !!
  - ~10% floating point content
    - ~70% is in 32bit mode
    - ~30% is in 64bit mode

```

83944504728489062 UNHALTED_CORE_CYCLES
73367226776016493 INSTRUCTIONS_RETIRED
10686337067594955 BRANCH_INSTRUCTIONS_RETIRED
   311480171783874 MISPREDICTED_BRANCH_RETIRED
24721876265962484 INST_RETIRED:LOADS
   2283757395310938 SIMD_COMP_INST_RETIRED:PACKED_SINGLE
                        :SCALAR_SINGLE:PACKED_DOUBLE:SCALAR_DOUBLE
12290157485830441 INST_RETIRED:STORES
   5471569673512022 X87_OPS_RETIRED:ANY
32749455427271767 RESOURCE_STALLS:ANY
   879105305211474 BUS_TRANS_ANY:ALL_AGENTS
   669442811829209 BUS_DRDY_CLOCKS:ALL_AGENTS
   25343960918275  BUS_BNR_DRV:ALL_AGENTS
   1249350584406064 LAST_LEVEL_CACHE_REFERENCES
   32338430323044  LAST_LEVEL_CACHE_MISSES
10798222210620212 CPU_CLK_UNHALTED:BUS

```

-----  
Ratios:

```

                                CPI: 1.1442
      load instructions %: 33.696%
      store instructions %: 16.752%
load and store instructions %: 50.448%
resource stalls % (of cycles): 39.013%
      branch instructions %: 14.566%
% of branch instr. mispredicted: 2.915%
      % of 12 loads missed: 2.588%
      bus utilization %: 16.282%
      data bus utilization %: 6.200%
      bus not ready %: 0.469%
comp. SIMD inst. ('new FP') %: 3.113%
comp. x87 instr. ('old FP') %: 7.458%

```

- Code seems relatively efficient – CPI of 1.17
- Few resource stalls
- Bus and data bus utilisations are very low
  - The *Bus Not Ready* percentage of 0.469% points to bus congestions under full load ... and “bursty” memory access patterns!!!!

```

83944504728489062 UNHALTED_CORE_CYCLES
73367226776016493 INSTRUCTIONS_RETIRED
10686337067594955 BRANCH_INSTRUCTIONS_RETIRED
   311480171783874 MISPREDICTED_BRANCH_RETIRED
24721876265962484 INST_RETIRED:LOADS
   2283757395310938 SIMD_COMP_INST_RETIRED:PACKED_SINGLE
                       :SCALAR_SINGLE:PACKED_DOUBLE:SCALAR_DOUBLE
12290157485830441 INST_RETIRED:STORES
   5471569673512022 X87_OPS_RETIRED:ANY
32749455427271767 RESOURCE_STALLS:ANY
   879105305211474 BUS_TRANS_ANY:ALL_AGENTS
   669442811829209 BUS_DRDY_CLOCKS:ALL_AGENTS
   25343960918275  BUS_BNR_DRV:ALL_AGENTS
   1249350584406064 LAST_LEVEL_CACHE_REFERENCES
   32338430323044  LAST_LEVEL_CACHE_MISSES
10798222210620212 CPU_CLK_UNHALTED:BUS
  
```

-----  
Ratios:

```

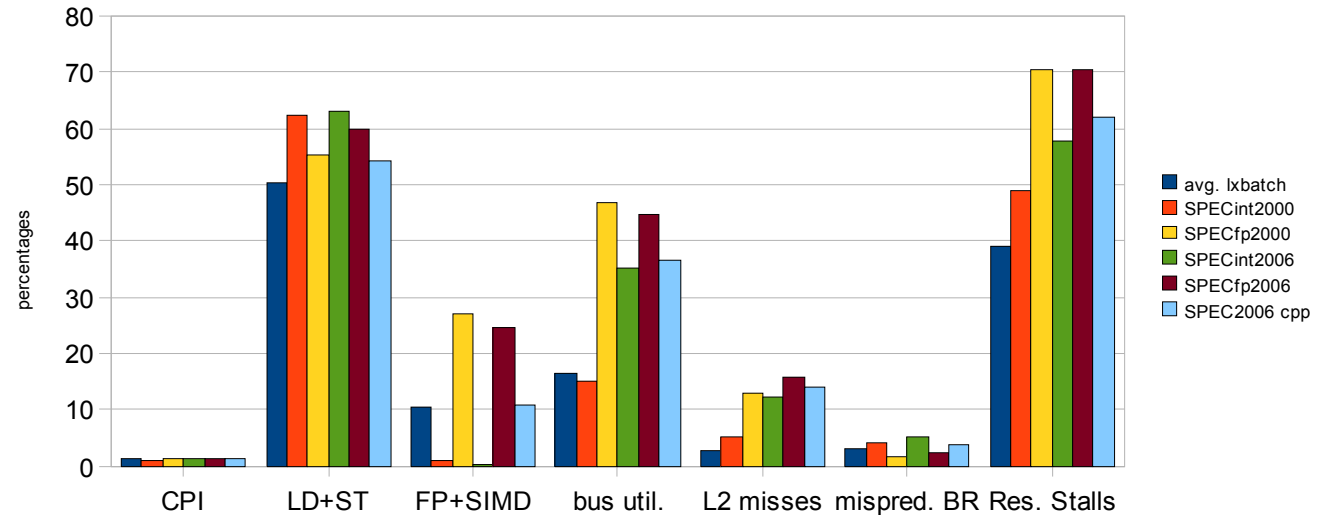
                                CPI: 1.1442
      load instructions %: 33.696%
      store instructions %: 16.752%
load and store instructions %: 50.448%
resource stalls % (of cycles): 39.013%
      branch instructions %: 14.566%
% of branch instr. mispredicted: 2.915%
      % of 12 loads missed: 2.588%
      bus utilization %: 16.282%
      data bus utilization %: 6.200%
      bus not ready %: 0.469%
comp. SIMD inst. ('new FP') %: 3.113%
comp. x87 instr. ('old FP') %: 7.458%
  
```



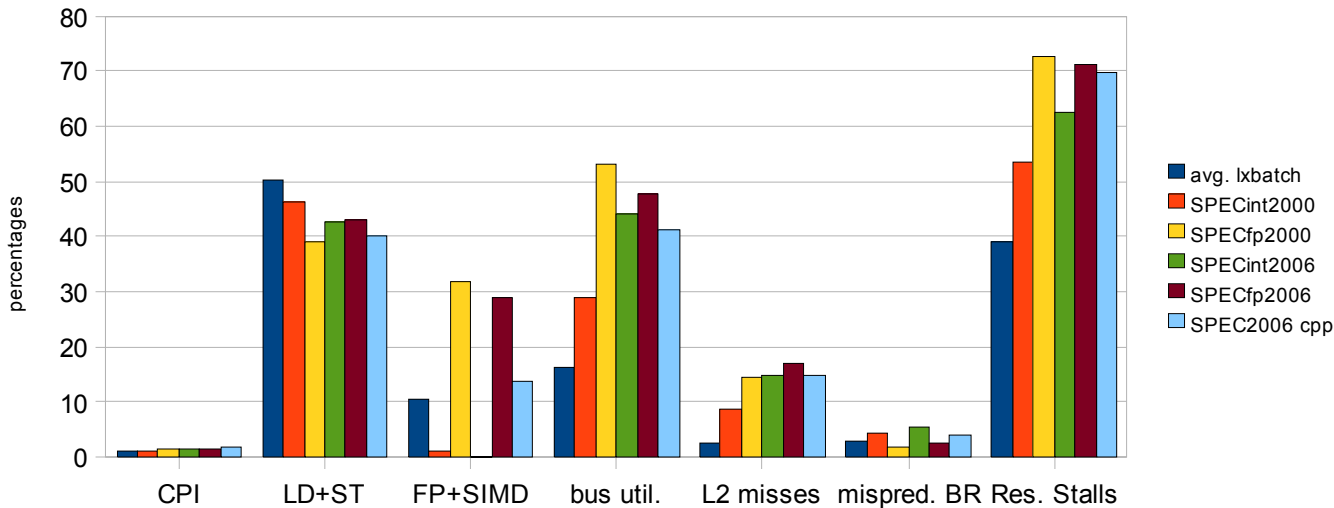
Lxbatch - everything	Lxbatch – under load (more than 87.5% of cycles used)
<pre> 83944504728489062 UNHALTED_CORE_CYCLES 73367226776016493 INSTRUCTIONS_RETIRED 10686337067594955 BRANCH_INSTRUCTIONS_RETIRED   311480171783874 MISPREDICTED_BRANCH_RETIRED 24721876265962484 INST_RETIRED:LOADS   2283757395310938 SIMD_COMP_INST_RETIRED:PACKED_SINGLE     :SCALAR_SINGLE:PACKED_DOUBLE:SCALAR_DOUBLE 12290157485830441 INST_RETIRED:STORES   5471569673512022 X87_OPS_RETIRED:ANY 32749455427271767 RESOURCE_STALLS:ANY   879105305211474 BUS_TRANS_ANY:ALL_AGENTS   669442811829209 BUS_DRDY_CLOCKS:ALL_AGENTS   25343960918275 BUS_BNR_DRV:ALL_AGENTS   1249350584406064 LAST_LEVEL_CACHE_REFERENCES   32338430323044 LAST_LEVEL_CACHE_MISSES 10798222210620212 CPU_CLK_UNHALTED:BUS           </pre>	<pre> 42144662725260216 UNHALTED_CORE_CYCLES 36103982787223754 INSTRUCTIONS_RETIRED   5360125638092404 BRANCH_INSTRUCTIONS_RETIRED     152446109206656 MISPREDICTED_BRANCH_RETIRED 12120993052849229 INST_RETIRED:LOADS   1121532429684894 SIMD_COMP_INST_RETIRED:PACKED_SINGLE     :SCALAR_SINGLE:PACKED_DOUBLE:SCALAR_DOUBLE   5970918951513077 INST_RETIRED:STORES   2539982276037386 X87_OPS_RETIRED:ANY 16566025785506481 RESOURCE_STALLS:ANY   474022962607770 BUS_TRANS_ANY:ALL_AGENTS   359724451168553 BUS_DRDY_CLOCKS:ALL_AGENTS   13925551815460 BUS_BNR_DRV:ALL_AGENTS   618434008358344 LAST_LEVEL_CACHE_REFERENCES   17859525620786 LAST_LEVEL_CACHE_MISSES   5293924072201402 CPU_CLK_UNHALTED:BUS           </pre>
<p>-----</p> <p>Ratios:</p> <pre>           CPI: 1.1442     load instructions %: 33.696%     store instructions %: 16.752% load and store instructions %: 50.448% resource stalls % (of cycles): 39.013%   branch instructions %: 14.566% % of branch instr. mispredicted: 2.915%   % of 12 loads missed: 2.588%     bus utilization %: 16.282%   data bus utilization %: 6.200%     bus not ready %: 0.469% comp. SIMD inst. ('new FP') %: 3.113% comp. x87 instr. ('old FP') %: 7.458%           </pre>	<p>-----</p> <p>Ratios:</p> <pre>           CPI: 1.1673     load instructions %: 33.572%     store instructions %: 16.538% load and store instructions %: 50.111% resource stalls % (of cycles): 39.308%   branch instructions %: 14.846% % of branch instr. mispredicted: 2.844%   % of 12 loads missed: 2.888%     bus utilization %: 17.908%   data bus utilization %: 6.795%     bus not ready %: 0.526% comp. SIMD inst. ('new FP') %: 3.106% comp. x87 instr. ('old FP') %: 7.035%           </pre>

# Pfmon – The Results – Overview

Comparison 32bit



Comparison 64bit



- None of the benchmarks looks like a perfect match to the results from Ixbatch ...
- ... but ... all C++ benchmarks from SPEC2006 are a pretty good match for
  - Floating Point content
  - Loads and stores
  - Mispredicted branches
- Very low bus utilisation on batch nodes
  - ... but ... *BNR* is quite high, pointing to a very uneven memory access pattern and congestion
- Batch machines running 2.6.24.x & pfmon are stable !!!!! ... and are actually ~10% faster ;-)

- New machines will go into production soon
  - Using the latest perfmon/pfmon
  - 50 boxes will be set up to run pfmon in system-wide mode
  - Statistics will significantly increase
  - Include the special queues for CMS and ATLAS
- Using pfmon to take a closer look at software from the experiments
- More measurements
  - with different compilers
  - On different systems (i.e. Harpertowns)
- Paper is being prepared