Performance analysis on Xeon

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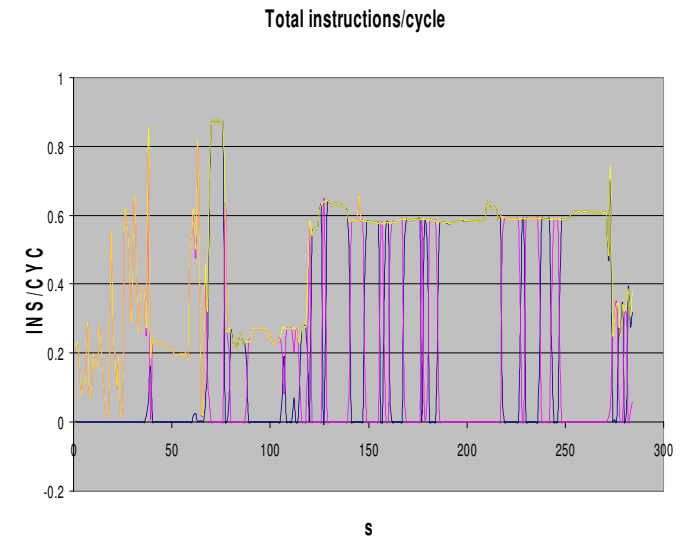
Ryszard Jurga
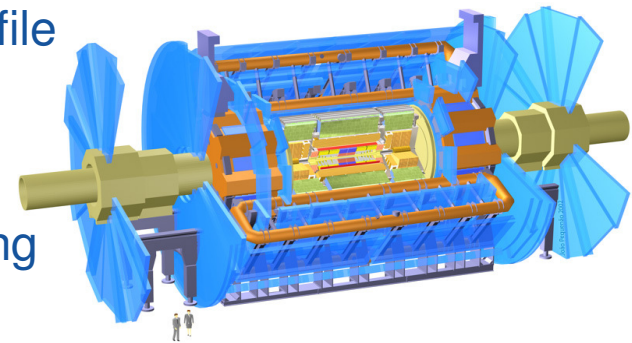
- ## Motivations
  - many jobs on multi processor/core boxes
  - the need of performance monitoring
  - profiling
  - bottleneck analysis and optimization
- ## Possibilities
  - Special on-chip hardware of modern CPU
    - direct access to CPU resources (number of cycles, integer and floating point, instructions, branch prediction and miss-prediction, cache misses etc
    - event detectors, counters
    - Itanium (100+,4), Montecito (200+,12)
    - Pentium4, Xeon (44,18)
  - Linux interfaces
    - Perfctr, Perfmon2
  - Linux tools:
    - pfmon, perfex, gpfmon, PerfSuite, q-tools, oprofile, caliper

Performance monitoring

Total instructions/cycle

- **Performance monitors**
  - Xeon
  - Itanium, Montecito (Martin B. Tingstad)
  - pfmon (perfmon2), perfex (perfctr)
  - libraries: libpfm, PAPI
  - gpfmon
    - perfctr, Xeon 32bit, 2.4 kernel, multiplexing, u/k domain, single/multi CPUs
    - lxbatch (Nocona, Irwindale, 2.4 kernel)
  - root, geant4 and SPEC benchmarks
  - real physics applications (e.g. Atlas simulation)
  - per thread/system-wide, counting/sampling mode
  - 60% LD+ST, 12-15% FP, 0.5 IPC, branches well predicted

- **Profiling (32bit mode, Xeon, PerfSuite)**
  - Atlas and LHCb simulations
    - full events, minimum bias
    - full stack (400+ dynamic libraries)
    - 80% time in geant4 libs, flat profile
  - Atlas reconstruction
    - inner detector
    - algorithms: iPatRec, new tracking
    - different particles
  - Geant4 libraries (Xeon, Itanium)
    - new examples (TestEm3,calorimeter)
    - different compilers and optimization levels (intel, gcc)
  - Providing access to our performance measurement machine for experiments

Example – TestEm3 functions

Function Summary

Samples	Self %	Total %	Function
601028	3.89%	3.89%	G4SteppingManager::DefinePhysicalStepLength()
591729	3.83%	7.71%	G4UniversalFluctuation::SampleFluctuations()
560752	3.63%	11.34%	G4PhysicsVector::GetValue()
538198	3.48%	14.82%	CLHEP::RanecuEngine::flat()
462588	2.99%	17.81%	G4SteppingManager::InvokePSDIP()
393428	2.54%	20.36%	G4MscModel::SampleCosineTheta()
374722	2.42%	22.78%	G4Track::GetVelocity() const
361544	2.34%	25.12%	__ieee754_exp
319502	2.07%	27.18%	G4SteppingManager::Stepping()
319273	2.06%	29.25%	G4VContinuousDiscreteProcess::PostStepGetPhysicalInteractionLength()
309086	2.00%	31.25%	G4VEnergyLossProcess::AlongStepDoIt()
308356	1.99%	33.24%	G4Transportation::AlongStepGetPhysicalInteractionLength()
302972	1.96%	35.20%	G4SteppingManager::InvokeAlongStepDoItProcs()
300388	1.94%	37.14%	G4MscModel::SampleSecondaries()
262319	1.70%	38.84%	__ieee754_log
255489	1.65%	40.49%	G4Navigator::ComputeStep()
242616	1.57%	42.06%	G4MscModel::GeomPathLength()
239758	1.55%	43.61%	exp
213537	1.38%	44.99%	log
211424	1.37%	46.36%	G4ParticleChange::CheckIt()
207567	1.34%	47.70%	G4Poisson()
199362	1.29%	48.99%	G4VDiscreteProcess::PostStepGetPhysicalInteractionLength()
195416	1.26%	50.26%	G4Transportation::AlongStepDoIt()
195074	1.26%	51.52%	SteppingAction::UserSteppingAction()
186097	1.20%	52.72%	CLHEP::Hep3Vector::rotateUz()
184364	1.19%	53.91%	G4VProcess::SubtractNumberOfInteractionLengthLeft()
180223	1.17%	55.08%	G4VEmProcess::GetMeanFreePath()
178297	1.15%	56.23%	log10
165481	1.07%	57.30%	G4SteppingManager::InvokePostStepDoItProcs()
162940	1.05%	58.36%	G4Transportation::PostStepDoIt()
154259	1.00%	59.35%	G4VEnergyLossProcess::GetContinuousStepLimit()
152030	0.98%	60.34%	G4Navigator::LocateGlobalPointWithinVolume()
149917	0.97%	61.31%	G4NormalNavigation::ComputeStep()
147770	0.96%	62.26%	__ieee754_log10
141567	0.92%	63.18%	G4Box::DistanceToOut() const
140319	0.91%	64.08%	G4MscModel::SampleDisplacement()
140158	0.91%	64.99%	G4Navigator::LocateGlobalPointAndSetup()
137387	0.89%	65.88%	G4VMultipleScattering::GetContinuousStepLimit()
135075	0.87%	66.75%	CLHEP::RandGaussQ::transformQuick()
129806	0.84%	67.59%	G4SandiaTable::GetSandiaCofPerAtom()
110959	0.72%	68.31%	G4NavigationLevelRep::G4NavigationLevelRep()
110321	0.71%	69.02%	G4Navigator::LocateGlobalPointAndUpdateTouchableHandle()
104521	0.68%	69.70%	G4MultipleScattering::TruePathLengthLimit()
104213	0.67%	70.37%	G4PhysicsLogVector::FindBinLocation()
103756	0.67%	71.04%	G4StepPoint::operator=()
101286	0.66%	71.70%	G4TouchableHistory::GetVolume()
97924	0.63%	72.33%	G4Box::DistanceToOut()
96843	0.63%	72.96%	G4ParticleChangeForTransport::UpdateStepForAlongStep()
96439	0.62%	73.58%	CLHEP::HepRotation::rotateAxes()
92988	0.60%	74.18%	memmove
89907	0.58%	74.76%	fabs
89003	0.58%	75.34%	G4VEnergyLossProcess::GetMeanFreePath()
88531	0.57%	75.91%	G4Box::Inside()
88290	0.57%	76.48%	G4NavigationLevel::~G4NavigationLevel()
88151	0.57%	77.05%	G4ParticleChangeForLoss::UpdateStepForAlongStep()
81527	0.53%	77.58%	__ieee754_acos
81446	0.53%	78.11%	CLHEP::HepRandom::getTheEngine()
80501	0.52%	78.63%	G4VContinuousDiscreteProcess::AlongStepGetPhysicalInteractionLength()

- Investigation of new releases of interfaces and tools and their new features on new CPUs (Woodcrest, 64bit OS) and new tools (callgrind)

- Continuation of the cooperation with experiments and geant4 team (e.g. I/O and POOL, 64bit experiment stack, tutorial)

- "Practical experience with Performance Monitors on Xeon and Itanium", Gelato conference in Singapore 2006