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# Abstract

Two parallelization techniques were adopted to parallelize a scientific application for reconstructing particle collisions. One, for a multicore shared memory environment, using OpenMP, and other for a heterogeneous parallel system with a GPU, using CUDA. A naïve implementation for both environments was made and presented in a previous report. In this report, the focus will be on analyzing the parallel region and identifying its bottlenecks, only for the multicore shared memory implementation. Two approaches to overcome these bottlenecks and a final performance analysis of the implementation are presented.

# Introdução

**O problema**

A maior parte das atividades humanas produz resíduos sólidos, o que comummente chamamos lixo [1]. O lixo é um dos problemas da comunidade global, normalmente é levado para aterros sanitários onde são acumulados, poluindo o ambiente.

Com o objetivo de reduzir este impacto ambiental foi criada a *política dos 3R’s* [4], que propõe que todos devem *R*eduzir a quantidade de lixo que produz (e.g. utilizar produtos de embalagem maiores para minimizar a quantidade de embalagens que serão resíduo), *R*eutilizar os recursos (e.g. reutilizar sacos de supermercado para embalar o lixo) e, por último e mais importante no âmbito deste projeto: *R*eciclar, ou seja, reaproveitar o material como matéria-prima para outro [2].

A título de exemplo, no grande Porto produziu-se 488 216.35 toneladas de resíduo no ano de 2011, dessas 53 796.73 toneladas foram recicladas [3], poupando o ambiente.

Para que a reciclagem se torne viável é necessário que os cidadãos separem o lixo reciclável do lixo indiferenciado, nós propomos um jogo que promove a reciclagem como algo positivo utilizando realidade aumentada.

**A aplicação**

Utilizando a biblioteca ARToolKit propomos o desenvolvimento de um jogo em que os jogadores utilizam padrões para movimentar luvas que apanham o lixo. Cada luva representa um tipo de lixo reciclável (e.g. embalagens, papel e cartão, vidro e lixo indiferenciado).

O objetivo do jogo é que o jogador consiga associar corretamente o lixo ao seu tipo, para depositá-lo no contentor correto.

# Dificuldades de implementação

Como prova de conceito desenvolvemos uma aplicação com as especificações indicadas, utilizando a biblioteca ARToolkKit.

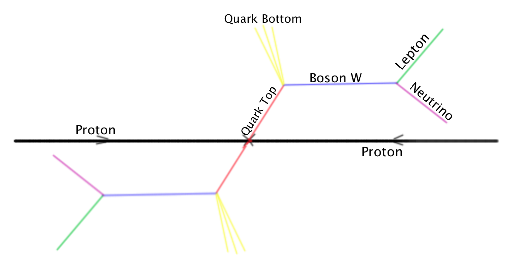


Figure 3.1 – Resulting particles from a head-on protons collision.

Since this system obeys a set of physic properties, the characteristics of the neutrino can be obtained by resolving a system of equations, based on the other particles characteristics, since its momentum and energy is conserved during the collision. The dilep routine solves this system using analytical methods. The objective is to run the dilep as many times as possible so that, within each event, a variance to the characteristics of the detected particles can be applied. This would help to take into account the experimental resolution of the detector and produce more physically accurate results for the neutrino, and system, characteristics.

# Testing Methodology

**Testing Environment**

To obtain the necessary data for the information presented in the next sections the Performance API (PAPI) [5] was used to access the CPU hardware counters. The time measurements were made using the function clock from GLIBC, the GNU C library [1], with millisecond precision (since each execution of the application was in the order of minutes, further precision is not required), as the system used for these measurements did not have the PAPI library available.

|  |  |  |
| --- | --- | --- |
| **CPUs** | **L1 Cache** | **L2 Cache** |
| Intel Xeon 5130 | 32 KB I.  32KB D. per Core | 4 MB shared |
| ***# Cores*** | ***# Threads*** | ***Clock Freq.*** |
| 2 | 2 | 2.0 GHz |

Table 4.1 – CPU on the multicore PAPI test system, compute-201-1.

All tests were executed in a linux Machine, the distribution was Cent OS 5.3, the linux kernel version was 2.6.32-71.29.1.el6.x86\_64 and the code was compiled with gcc 4.4.6.

**Testing Methodology**

The tests are divided between two systems because the scaling of the parallel region cannot be properly measured in the compute-201-1 system, as it only has 4 cores (with no multithreading) and its technology is outdated. The compute-611-2 system offers a better environment to study the parallelization scaling, up to 24 threads with multithreading.

# Conclusion

We were presented with a scientific application, which the objective was to improve its performance. Instead of determining in which region of the code the application was spending the most computational time and resources, the goal was to increase the number of executions of a specific function, dilep, which, in the original application, was not the bottleneck. However, when the number of dilep executions was increased, as presented in the previous report, it quickly became the routine spending most of the time in the application.

References

1. Wikipedia, a enciclopédia livre, *Resíduo Sólido*, retirado em 10-06-2012.
2. Wikipedia, a enciclopédia livre, *Reciclagem*, retirado em 10-06-2012.
3. LIPOR – Serviço Intermunicipalizado de Gestão de Resíduos do Grande Porto, *Relatório de Análise Estatística LIPOR*, [2012?], retirado em 10-06-2012.
4. Tuguca, *Três R’s: Reduzir, Reutilizar e Reciclar*, in www.inxinet.com, retirado em 10-062012.