Briefing of PAC'14

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Chapter 1

Event Background

PAC2014 (Parallel Application Challenge 2014) is a national HPC application competition of China. It is held by CCF-TCHPC (China Computer Federation, Technical Committee on High Performance Computing), Intel China and organized by *PARATERA*(Beijing PARATERA Tech Co.,Ltd). The challenge started in 2013 while it develops fast and achieves a great nation-wide success. This year the number of attending teams increased by 3 times compared to the last year. The challenge of 2014 aims to boost the development of Intel's Xeon Phi programming in China, and thus has got substantial support from Intel China.

1.1 The Agenda of PAC2014

PAC2014 organize 2 parallel sessions for the contest: 1) The best application 2) The best scalability. On the way to the top prizes, each team should go through a preliminary contest, a semi-final and the final contest. Before the preliminary contest, every team in China has accepted a summer school training course specially for the Xeon Phi programming.

1.1.1 Preliminary Contest

The Preliminary Contest was from 31 August to 14 September. All the prestigious universities and institutions of China have sent their teams to this event. During this phase, the teams are regrouped according to their region (North China, East China, Central and South China, NorthEast and West China). Each team should provide their own application as its contest subject. Their submission should include the following contents:

- A report and a slide for presenting their work.
- A log file and results files as a proof of their execution on machines.
- The source code of application, but is not compulsory.

The review of the work has been done by the PAC2014 committee. Each team's work is firt reviewed by all the 15 committee members. Each committee member gave out their adjudgement and ratings. If any work has a large variance of ratings, it shall be reviewed again in a second turn by all the members. By doing so, 24 teams have won their tickets to the semi-final contest, and their work would be exposed in the website to the public.

1.1.2 Semi-Final Contest

The Semi-Final Contest has began in 15 September and ended in 28 September. Each of the 24 team have time to improve their own work. The evaluation of their work is decided by the committee and the votes from each team's supporters of network polls. In Semi-Final Contest, the committee also invited a foreign team which comes from a French HPC laboratory, *Maison de la Simulation*. By the end of this phase, less than 10 teams would be selected to enter the final phase. Table 1.1 gives out all the teams running for best scalability in the final round.

Table 1.1: Teams for the Best Scalability

Team Name	Subject
Peking University	A Parallel Dark Channel Prior Algorithm
NUDT team 1	Lattice Boltzmann methods (LBM) in CFD simulation
Shanghai Jiaotong Univ	3D Elastic Wave Modeling
USTC	Binomial model based Option Price
IPE,CAS	Molecular Dynamics Simulation
ICT,CAS	High efficient SVD on MIC
CNIC& National Observatory	NMaker: a new N-body numerical simulation software
ISCAS	Parallel Optimization of aerography software Package *MPAS*
Maison de la Simulation, France	Parallel Computing of Discrete Time Hedging Error

Table 1.2 presents all the teams competing for best application in the final round.

Table 1.2: Teams for the Best Application

Team Name	Subject
Peking University & Dalian CAS	Gromacs optimization on MIC platform
NUDT team 0	BigData in bioinformation DNA analysis
NUDT team 1	Lattice Boltzmann methods (LBM) in CFD simulation
IPE,CAS	Molecular Dynamics Simulation
CNIC& National Observatory	NMaker: a new N-body numerical simulation software
Dalian CAS	Protein molecular dynamics Simulation based on quantum mechanics
Maison de la Simulation, France	Parallel Computing of Discrete Time Hedging Error

Part of the Semi-Final Contest work would be selected as Application cases to be published in China HPC annual conference 2014.

1.1.3 Final Contest

The Final Contest shall be held during HPC China annual conference 2014 in Guangzhou. The competition for the *Best Application* is based on the improvement of their Semi-Final work. While the contest of the *Best Scalability* is based on *the optimization of Gromacs software on Tianhe2A*. The workload would be released on 15th october. The resource provided by the organizer includes 8 nodes from the Tianhe2A cluster and the source codes of Gromacs software both in CPU version and MIC version (symmetric mode). The optimization object is to maximize the performance (minimize the walltime) of Gromacs without undermining the correctness and accuracy. The optimization codes must run on the computing resource provided by the organizer. All teams in Final Contest shall present their work and answer the questions from the jury and audience in the conference. A voting process of the audience is also considered in the final decision.

Chapter 2

Subject description

The subject choosing is free to all participants. The goal is to provide a parallel application with a sound scalability. What we chose to do is a financial problem. In the real practice a hedging process can only be carried out in discrete time points. Then an error could be generated when the model is continuous. We want to lower the trading frequency (discretisation of the studied timeline) in hedging while retaining the error within an acceptable level. A mathematical lowest upper bound was raised in this work, which's the best estimation for the time being. We then use the Monte Carlo Simulation to heuristically find the best suited discretisation of the underlying problem.

2.1 Mathematical modeling of the project

Equation 2.1 gives the discrete time hedging error for one time simulation. The goal is to simulate M times where M is sufficiently large so that the $Prob$ tends to be stable. The $Prob$ is defined as the number of times out of M when error is less than an accepted value ϵ.

$$
\begin{aligned}
M_T^N &= e^{-rT} f(X_T) - (u(0,x) + \int_0^T \frac{\partial u}{\partial x}(\varphi(t), X_{\varphi_t})) d\widetilde{X}_t \\
&= \int_0^T \frac{\partial u}{\partial x}(t, X_t) d\widetilde{X}_t - \int_0^T \frac{\partial u}{\partial x}(\varphi(t), X_{\varphi(t)}) d\widetilde{X}_t \\
&= (X_T - K)^+ - \mathbb{E}[(X_T - K)^+] - \int_0^T \frac{\partial u}{\partial x}(\varphi(t), X_{\varphi(t)}) dX_t \\
&= (X_T - K)^+ - x_0 N(d_1(0)) + K N(d_2(0)) - \sum_{i=0}^{n-1} N(d_1(t_i))(X_{t_{i+1}} - X_{t_i}) \\
&= (X_T - K)^+ - \frac{x_0}{\sqrt{2\pi}} \int_{-\infty}^{\frac{\log(\frac{x_0}{K}) + \frac{1}{2}\sigma^2 T}{\sigma\sqrt{T}}} e^{-\frac{v^2}{2}} dv + \frac{K}{\sqrt{2\pi}} \int_{-\infty}^{\frac{\log(\frac{x_0}{K}) - \frac{1}{2}\sigma^2 T}{\sigma\sqrt{T}}} e^{-\frac{v^2}{2}} dv \\
&\quad - \sum_{i=0}^{n-1} \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\frac{\log(\frac{X_{t_i}}{K}) + \frac{1}{2}\sigma^2 (T - t_i)}{\sigma\sqrt{T - t_i}}} e^{-\frac{v^2}{2}} dv (X_{t_{i+1}} - X_{t_i})
\end{aligned}
\tag{2.1}
$$

The X_t is the price of the underlying asset for the option, which is assumed to evolve in time according to the stochastic equation

$$dX(t) = \mu X(t) dt + \sigma X(t) dB(t) \tag{2.2}$$

In this equation, μ is the drift of the asset, σ is the option volatility, and $B(t)$ is a standard Brownian motion.

The solution of this stochastic differential equation can be written as

$$X_{t_i} = X_{t_{i-1}} e^{(\mu - \sigma^2/2)\delta t + \sigma\sqrt{\delta t}\chi} \tag{2.3}$$

where χ is a normally distributed random variable with zero mean and unit standard deviation, and $\delta t = t_i - t_{i-1}$.

By our unpublished theory, the upper bound of N (discrete intervals of hedging) is given by Equation 2.4, which's the best estimation (the lowest upper bound) for the time being.

$$N_{max} = \log^3(1 - Prob)e^{\frac{1}{4}} \frac{1}{T^{\frac{1}{4}}\sqrt{\frac{\epsilon}{(\log\frac{X_0}{K}+0.5\sigma^2 T)\sqrt{2\pi}}}} \cdot (-\frac{8e^3X_0^2 \cdot 16 \cdot e^{\sigma^2}}{27\epsilon^2\pi}) \tag{2.4}$$

There's one more thing to mention, we've implemented our own gaussian integral function using Simpson's rule. See equations 2.5 and 2.6.

$$\int_a^b f(x)dx \approx \frac{h}{3}\left[f(x_0) + 2\sum_{j=1}^{n/2-1} f(x_{2j}) + 4\sum_{j=1}^{n/2} f(x_{2j-1}) + f(x_n)\right] \tag{2.5}$$

$$f(x) = \int_{-\infty}^{x} e^{-\frac{t^2}{2}}dt = 0.5 \times \sqrt{2\pi} + \int_0^x e^{-\frac{t^2}{2}}dt \tag{2.6}$$