

一、简介

HPL 是针对现代并行计算机提出的测试方式，Linpack 是国际上最流行的用于测试高性能计算机系统浮点性能的 benchmark。通过对高性能计算机采用高斯消元法求解一元 N 次稠密线性代数方程组的测试，评价高性能计算机的浮点性能。

用户在不修改任意测试程序的基础上，可以调节问题规模大小(矩阵大小)、使用 CPU 数目、使用各种优化方法等等来执行该测试程序，以获取最佳的性能。HPL 采用高斯消元法求解线性方程组。求解问题规模为 N 时，浮点运算次数为 $(2/3 * N^3 - 2*N^2)$ 。因此，只要给出问题规模 N，测得系统计算时间 T，峰值=计算量 $(2/3 * N^3 - 2*N^2)$ / 计算时间 T，测试结果以浮点运算每秒(Flops)给出，衡量计算机性能的一个重要指标就是计算峰值或者浮点计算峰值。HPL 测试结果是 TOP500 排名的重要依据。

在比赛中，参赛队正确安装和编译 HPL 包之后，通过一定的配置修改，开始运行 HPL，HPL 的运行方式和 MPI 密切相关，不同的 MPI 在运行方面有一定的差别。运行结束输出结果后，参赛队需要针对实际测试结果进行分析，不断修改配置，优化测试，以取得满意的结果。

二、环境搭建

- 1. 各计算节点安装 linux 操作系统
- 2. 配置网络结构，保证各节点间具备高效的通讯带宽
- 3. 各节点间配置 ssh 或 rsh 无密码访问
- 4. 安装 C 语言及 Fortran77 编译器
- 5. 安装编译数学库，常用为 BLASGOTO
- 6. 安装配置并行环境：MPI 消息传递接口
- 7. 安装配置 LINPACK 测试包
- 8. 利用 MPI 运行测试，获取最终计算结果。

三、修改 HPL 参数

```
HPL.dat |
1  HPLinpack benchmark input file
2  Innovative Computing Laboratory, University of Tennessee
3  HPL.out      output file name (if any)
4  6            device out (6=stdout,7=stderr,file)
5  4           # of problems sizes (N)
6  386 768 800 1000      Ns
7  4           # of NBs
8  32 64 128 16         NBs
9  1           PMAP process mapping (0=Row-,1=Column-major)
10 1           # of process grids (P x Q)
11 2           Ps
12 2           Qs
13 16.0       threshold
14 1           # of panel fact
15 2           PFACTs (0=left, 1=Crout, 2=Right)
16 2           # of recursive stopping criterium
17 2 4        NBMINs (>= 1)
18 1           # of panels in recursion
19 2           NDIVs
20 3           # of recursive panel fact.
21 0 1 2       RFACTs (0=left, 1=Crout, 2=Right)
22 1           # of broadcast
23 0           BCASTs (0=1rg,1=1rM,2=2rg,3=2rM,4=Lng,5=LnM)
24 1           # of lookahead depth
25 0           DEPTHS (>=0)
26 2           SWAP (0=bin-exch,1=long,2=mix)
27 64         swapping threshold
28 0           L1 in (0=transposed,1=no-transposed) form
29 0           U  in (0=transposed,1=no-transposed) form
30 1           Equilibration (0=no,1=yes)
31 8           memory alignment in double (> 0)
```

四、测试结果：

```
=====
HPLinpack 2.3 -- High-Performance Linpack benchmark -- December 2, 2018
Written by A. Petitet and R. Clint Whaley, Innovative Computing Laboratory, UTK
Modified by Piotr Luszczek, Innovative Computing Laboratory, UTK
Modified by Julien Langou, University of Colorado Denver
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An explanation of the input/output parameters follows:
T/V   : Wall time / encoded variant.
N     : The order of the coefficient matrix A.
NB    : The partitioning blocking factor.
P     : The number of process rows.
Q     : The number of process columns.
Time  : Time in seconds to solve the linear system.
Gflops : Rate of execution for solving the linear system.

The following parameter values will be used:

N      : 386 768 800 1000
NB     : 32 64 128 16
PMAP   : Column-major process mapping
P      : 2
Q      : 2
PFACT  : Right
NBMIN  : 2 4
NDIV   : 2
RFACT  : Left Crout Right
BCAST  : 1ring
DEPTH  : 0
SWAP   : Mix (threshold = 64)
L1     : transposed form
U      : transposed form
EQUIL  : yes
ALIGN  : 8 double precision words

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- The matrix A is randomly generated for each test.
- The following scaled residual check will be computed:
  ||Ax-b||_oo / ( eps * ( || x ||_oo * || A ||_oo + || b ||_oo ) * N )
- The relative machine precision (eps) is taken to be 1.110223e-16
- Computational tests pass if scaled residuals are less than 16.0

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```

||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)= 3.74348099e-03 PASSED
=====

T/V	N	NB	P	Q	Time	Gflops

WC00R2R2	1000	16	2	2	3.51	1.9046e-01

HPL_pdgesv() start time Tue Dec 24 15:04:42 2019

HPL_pdgesv() end time Tue Dec 24 15:04:46 2019

||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)= 3.66035211e-03 PASSED
=====

T/V	N	NB	P	Q	Time	Gflops

WC00R2R4	1000	16	2	2	3.39	1.9722e-01

HPL_pdgesv() start time Tue Dec 24 15:04:46 2019

HPL_pdgesv() end time Tue Dec 24 15:04:49 2019

||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)= 3.74348099e-03 PASSED
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Finished 96 tests with the following results:
96 tests completed and passed residual checks,
0 tests completed and failed residual checks,
0 tests skipped because of illegal input values.

End of Tests.
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