High Performance Computing

2023 Fall

Lab 8. High Performance Linpack

Yongzhuo Ma

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Chapter 1

Introduction to the Environment

1.1 Host Machine

Item	Value
OS version	macOS Sonoma 14.0
Apple clang version	15.0.0
CPU	Apple M2 Max
CPU Frequency	3.54 - 3.70 GHz
CPU Cores	12
Memory	64 GB
Memory Bandwidth	400 GB/s

1.2 Virtual Machine

Item	Value
Virtualization	Parallels
OS version	Ubuntu 22.04.3 LTS
gcc version	11.4.0
CPU	Apple M2 Max
CPU Frequency	3.69 GHz
CPU Cores	12
Memory	32 GB

1.3 Dependencies

Item	Version
OpenBLAS	0.3.24
OpenMPI	4.1.4
MPICH	4.0
ATLAS	3.10.3
HP Linpack	2.3

Chapter 2

HPL Tuning

In this chapter, I will share my experience on tuning **HPL.dat** to reach a higher GFlops.

Design the function pointer part:
The key part except the algorithm is Ns and NBs.
When Ns and NBs increases, GFlops will increases and then decreases. First we can change the threshold to a negative number to bypass checking. And we set Ns to a smaller value, let us say 20352. Then we modify NBs. A benchmark will be completed in about 60 seconds. And then we change Ns. Finally I decided :

Ns : 58368

NBs : 192 for OpenBLAS+OpenMPI and 768 for ATLAS+MPICH

Problems and solution

1. Only 1 process can be run simutanously.

Solution:

CPU virtualization problem.

It seemed that the cores allocated to the VM were not virtualized as physical cores, but as a cluster. The problem solved through regarding the number of cores as 1.

2.1 OpenBLAS+OpenMPI

```
================================================================================
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
================================================================================

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      :   58368
NB     :     192
PMAP   : Row-major process mapping
P      :       1
Q      :       1
PFACT  :   Right
NBMIN  :       4
NDIV   :       2
RFACT  :   Crout
BCAST  :  1ringM
DEPTH  :       1
SWAP   : Mix (threshold = 64)
L1     : transposed form
U      : transposed form
EQUIL  : yes
ALIGN  : 8 double precision words

--------------------------------------------------------------------------------

- 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

================================================================================
T/V                N    NB     P     Q               Time                 Gflops
--------------------------------------------------------------------------------
WR11C2R4       58368   192     1     1             397.29             3.3369e+02
HPL_pdgesv() start time Sun Oct  8 17:38:13 2023

HPL_pdgesv() end time   Sun Oct  8 17:44:50 2023

--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=   3.51798211e-03 ...... PASSED
================================================================================

Finished      1 tests with the following results:
              1 tests completed and passed residual checks,
              0 tests completed and failed residual checks,
              0 tests skipped because of illegal input values.
--------------------------------------------------------------------------------

End of Tests.
================================================================================
```

2.2 ATLAS+MPICH

```
================================================================================
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
================================================================================

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      :   58368
NB     :     768
PMAP   : Row-major process mapping
P      :       1
Q      :       1
PFACT  :   Right
NBMIN  :       4
NDIV   :       2
RFACT  :   Crout
BCAST  :  1ringM
DEPTH  :       1
SWAP   : Mix (threshold = 64)
L1     : transposed form
U      : transposed form
EQUIL  : yes
ALIGN  : 8 double precision words

--------------------------------------------------------------------------------

- 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

================================================================================
T/V                N    NB     P     Q               Time                 Gflops
--------------------------------------------------------------------------------
WR11C2R4       58368   768     1     1             774.08             1.7126e+02
HPL_pdgesv() start time Mon Oct  9 13:15:17 2023

HPL_pdgesv() end time   Mon Oct  9 13:28:11 2023

--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=   3.71973057e-03 ...... PASSED
================================================================================

Finished      1 tests with the following results:
              1 tests completed and passed residual checks,
              0 tests completed and failed residual checks,
              0 tests skipped because of illegal input values.
--------------------------------------------------------------------------------

End of Tests.
================================================================================
```