PMlib講習会後半　実習編

PMlibのインストールとテスト

- ゲスト無線LANの使用について（別資料）
- PMlibパッケージの入手方法
- テストシステムへのログイン
- PMlibのインストール
- exampleプログラムの実行

PMlibパッケージの入手方法

- （公式な）PMlibパッケージ公開リポジトリ
  - http://avr-aics-riken.github.io/PMlib/
- PMlib開発用共有リポジトリ
  - http://github.com/avr-aics-riken/PMlib/
- 本日は以下のリポジトリからPMlib最新開発版を使用する
  - https://github.com/mikami3heart/PMlib/
    - Webブラウザで右上の clone or download ボタンから Download ZIP
    - ファイル名：PMlib-master.zip
- インストールに関する資料
  - https://github.com/mikami3heart/PMlib-tutorials/
    - 本資料（スライド） ファイル名：Tutorial-slide2-installation.pdf
    - 利用手引き説明書　ファイル名：PMlib-5.0-user-manual.pdf
    - 参考スクリプトファイル名：scripts.K.tar.gz

京コンピュータでの実習
PMlibのインストール

PMlibのインストール　京コンピュータ(1)

- 本日はログインノードでPMlibをインストールする。
  - アプリケーションは計算ノードで実行される。
  - （インストールはログインノードでも計算ノードでも可能）
- Webブラウザでダウンロードした PMlib-master.zipを使う
  - このファイルを京コンピュータログインノードへ転送する
  - （本日京コンピュータ以外のシステムをリモート利用して実習参加の方は、各環境にあわせて以下読み替えて下さい）

公式版PMlibのインストール　京コンピュー(2)

- 京コンピュータの適当なディレクトリにパッケージを転送する

```
myPC$  ssh  ログイン名@k.aics.riken.jp ls -go
myPC$  ssh  ログイン名@k.aics.riken.jp mkdir –p pmlib/tar_balls
myPC$  scp  avr*PMlib*.tar.gz  ログイン名@k.aics.riken.jp:pmlib/tar_balls
```

- 京コンピュータへログインし、パッケージを展開する

```
myPC$  ssh  ログイン名@k.aics.riken.jp

K$  ls  pmlib/tar_balls/avr*PMlib*tar.gz
K$  cd pmlib
K$  tar –zxf  tar_balls/avr*PMlib*tar.gz
K$  ln –s  avr*PMlib*  PMlib
K$  ls –go
lrwxrwxrwx  1   28 2015-08-24 PMlib -> avr-aics-riken-PMlib-ced9279
drwxr-xr-x  9 4096 2015-08-24 avr-aics-riken-PMlib-ced9279
drwxr-xr-x  2 4096 2015-08-24 tar_balls
```

開発版PMlibのインストール　京コンピュータ(2)

- 京コンピュータの適当なディレクトリにパッケージを転送する

```
myPC$  ssh  ログイン名@k.aics.riken.jp ls -go
myPC$  ssh  ログイン名@k.aics.riken.jp mkdir –p pmlib/tar_balls
myPC$  scp  PMlib-master.zip  ログイン名@k.aics.riken.jp:pmlib/tar_balls
```

- 京コンピュータへログインし、パッケージを展開する

```
myPC$  ssh  ログイン名@k.aics.riken.jp

K$ hostname
fe01p02
K$  ls  pmlib/tar_balls/PMlib-master.zip
K$  cd pmlib
K$  unzip tar_balls/PMlib-master.zip
K$  ln –s  PMlib-master  PMlib
K$  ls –go
lrwxrwxrwx  1   12 2016-06-21 15:15 PMlib -> PMlib-master
drwxr-xr-x 10 4096 2016-06-21 15:13 PMlib-master
drwxr-xr-x  2 4096 2016-06-21 15:11 tar_balls
```

PMlibのインストール　京コンピュータ(3)

- ログインノード上で以下のコマンドで MPI版をmake する。

```
K$ INSTALL_DIR=${HOME}/pmlib/install_dir
K$ SRC_DIR=${HOME}/pmlib/PMlib
K$ BUILD_DIR=${SRC_DIR}/BUILD_DIR
K$ cd $BUILD_DIR; if [ $? != 0 ] ; then echo '@@@ Directory error @@@'; exit; fi
K$
K$ CFLAGS="-std=c99 -Kopenmp,fast -Ntl_notrt -w"
K$ FCFLAGS="-Cpp -Kopenmp,fast -Ntl_notrt -w -Knooptmsg"
K$ CXXFLAGS="-Kopenmp,fast -Ntl_notrt -w"
K$
K$ ../configure CXX=mpiFCCpx CC=mpifccpx FC=mpifrtpx \
   CXXFLAGS="${CXXFLAGS}" CFLAGS="${CFLAGS}" FCFLAGS="${FCFLAGS}" \
   --with-comp=FJ --host=sparc64-unknown-linux-gnu \
   --with-papi=yes --with-example=yes --prefix=${INSTALL_DIR}
K$ make
K$ make install
```

- あるいは

```
K$   ./x.make-pmlib-K.sh
```

PMlibのインストール　京コンピュータ(4)

- インストール時の標準出力メッセージ例

```
K$   ./x.make-pmlib-K.sh
+ ../configure CXX=mpiFCCpx CC=mpifccpx FC=mpifrtpx  …
----------------------------------
Running PMlib Configure Script
----------------------------------
checking for a BSD-compatible install... /usr/bin/install –c
   …
------------------------------------------
Finished Running PMlib Configure Script
------------------------------------------
+ make
make  all-recursive
make[1]: ディレクトリ `${HOME}/pmlib/PMlib/BUILD_DIR' に入ります
   … (かなりメッセージが表示されますが、無害なものです）
make[1]: ディレクトリ `${HOME}/pmlib/PMlib/BUILD_DIR' から出ます
+ make install
   …
make[1]: ディレクトリ `${HOME}/pmlib/PMlib/BUILD_DIR' から出ます
```

PMlibのインストール　京コンピュータ(5)

- exampleプログラムがmakeされた事を確認する

```
K$  cd PMlib/BUILD_DIR/example
K$  ls -go test?/test?
-rwxr-xr-x 1 4455942 2016-06-21 23:00 test1/test1
-rwxr-xr-x 1 4456240 2016-06-21 23:00 test2/test2
-rwxr-xr-x 1 4460921 2016-06-21 23:00 test3/test3
-rwxr-xr-x 1 4459978 2016-06-21 23:00 test4/test4
-rwxr-xr-x 1 4460921 2016-06-21 23:00 test5/test5
K$  file test?/test?
test1/test1: ELF 64-bit MSB executable, SPARC V9, total store ordering, version 1
(SYSV), dynamically linked (uses shared libs), for GNU/Linux 2.6.12, not stripped
test2/test2: ELF 64-bit MSB executable, SPARC V9, total store ordering, version 1
(SYSV), dynamically linked (uses shared libs), for GNU/Linux 2.6.12, not stripped
test3/test3: ELF 64-bit MSB executable, SPARC V9, total store ordering, version 1
(SYSV), dynamically linked (uses shared libs), for GNU/Linux 2.6.12, not stripped
test4/test4: ELF 64-bit MSB executable, SPARC V9, total store ordering, version 1
(SYSV), dynamically linked (uses shared libs), for GNU/Linux 2.6.12, not stripped
test5/test5: ELF 64-bit MSB executable, SPARC V9, total store ordering, version 1
(SYSV), dynamically linked (uses shared libs), for GNU/Linux 2.6.12, not stripped
```

京コンピュータでの実習
例題プログラムの対話的実行

example/に含まれる例題プログラム

- 以下の例題プログラムが含まれる
  - test1: C++主プログラムからのPMlib呼び出し
  - test2: C++とCの混合プログラムでPMlibの呼び出し(C++から)
  - test3: プロセスgroupを明示的に生成するプログラムからの呼び出し
  - test4: fortranプログラムからのPMlibの呼び出し
  - test5: MPI_Comm_splitでコミュニケータを分割したプログラムに対してプロセスを自動group化してレポート出力
- PMlibライブラリと例題プログラムは同じconfigureオプションでmakeされる
  - configureオプションの詳細は INSTALLファイル又は利用説明書を参照
- MPIプログラムとしてテスト可能なのは
  - test1, test2, test3, test4, test5
  - コンパイル時のマクロ _PM_WITHOUT_MPI_ 未定義(-U)で自動生成
- シリアルプログラムとしてテスト可能なのは
  - test1, test2, test4
  - コンパイル時のマクロ _PM_WITHOUT_MPI_ 定義(-D)で自動生成

PMlib例題プログラムの対話的実行　京コンピュータ

- 京の計算資源は大変込み合っているため、各自で計算ノード1台のみを利用する対話的ジョブを起動し、以降の実習を進める
- makeされたexample/test1プログラムを計算ノード上で対話的実行

```
K$  pwd
${HOME}/pmlib/PMlib/BUILD_DIR/example
K$  pjsub --interact --rsc-list "elapse=01:00:00" --rsc-list "node=1" --mpi "proc=2"
[INFO] PJM 0000 pjsub Job 2955440 submitted.
[INFO] PJM 0081 ....connected.
[INFO] PJM 0082 pjsub Interactive job 2955440 started.
Env_base: K-1.2.0-18
```

```
K$ hostname
g05-040
K$ pwd
${HOME}/pmlib/PMlib/BUILD_DIR/example
K$  /opt/FJSVXosPA/bin/xospastop
K$  export OMP_NUM_THREADS=4  NPROCS=2
K$  mpiexec -n ${NPROCS} ./test1
```

PMlib例題プログラムのバッチ実行　京コンピュータ

- 前ページと同じジョブをバッチジョブとして投入実行する例
- #PJM --stgin-basedir のパス名は各自修正する

```
K$  cat x.run-test1.sh
#!/bin/bash
#PJM -N MYTEST1
#PJM --rsc-list "elapse=1:00:00"
#PJM --rsc-list "node=1"
#PJM --mpi "proc=2”
#PJM -j
#PJM -S
# stage io files
#PJM --stg-transfiles all
#PJM --mpi "use-rankdir"
#PJM --stgin-basedir "/home/ra000004/a03155/pmlib/PMlib/BUILD_DIR/example"
#PJM --stgin "rank=* test1/test1 %r:./test1”
source /work/system/Env_base
/opt/FJSVXosPA/bin/xospastop
export OMP_NUM_THREADS=4  NPROCS=2
mpiexec -n ${NPROCS} ./test1

K$  pjsub  x.run-test1.sh
```

京コンピュータ: test1の実行結果例

基本レポート:環境変数 HWPC_CHOOSERの指定なしー＞計算量自己申告モード

```
# PMlib Basic Report -----------------------------------------------------

      Timing Statistics Report from PMlib version 5.0.4
      Linked PMlib supports: MPI, OpenMP, HWPC, no-OTF
      Host name : g05-040
      Date      : 2016/06/22 : 01:27:48
      Mrs. Kobe
      Parallel Mode:   Hybrid (2 processes x 4 threads)
      The environment variable HWPC_CHOOSER is not provided. No HWPC report.

      Total execution time            = 2.008230e+00 [sec]
      Total time of measured sections = 2.000537e+00 [sec]

      Exclusive sections statistics per process and total job.
      Inclusive sections are marked with (*)

      Section           |    call  |        accumulated time[sec]                 | [user defined counter values ]
      Label             |          |      avr    avr[%]      sdv    avr/call     |      avr       sdv    speed
      ------------------+----------+-----------------------------------------------+-------------------------
      Second section(*) :        1   1.736e+00   86.80   8.58e-03   1.736e+00     2.800e+10   0.00e+00   16.12 Gflops(*)
      Subsection Y      :        3   7.010e-01   35.04   1.05e-03   2.337e-01     1.200e+10   0.00e+00   17.12 Gflops
      Subsection X      :        3   6.988e-01   34.93   7.66e-04   2.329e-01     4.800e+10   0.00e+00   68.69 GB/sec
      First section     :        1   2.311e-01   11.55   6.98e-04   2.311e-01     4.000e+09   0.00e+00   17.31 Gflops
      ------------------+----------+-----------------------------------------------+-------------------------
      Sections per process          9.321e-01      -Exclusive CALC sections-     1.600e+10              17.17 Gflops
      Sections per process          6.988e-01      -Exclusive COMM sections-     4.800e+10              68.69 GB/sec
      ------------------+----------+-----------------------------------------------+-------------------------
      Sections total job            9.321e-01      -Exclusive CALC sections-     3.200e+10              34.33 Gflops
      Sections total job            6.988e-01      -Exclusive COMM sections-     9.600e+10             137.38 GB/sec
```

京コンピュータ: test1の実行結果例

詳細レポート：各測定区間毎に全MPIランクのレポート

```
# PMlib Process Report --- Elapsed time for individual MPI ranks ------

Label  Subsection Y
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     0 :        3  7.017e-01   35.1  0.000e+00  2.339e-01  1.200e+10  1.710e+10 Flops
Rank     1 :        3  7.002e-01   35.0  1.488e-03  2.334e-01  1.200e+10  1.714e+10 Flops
Label  Subsection X
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     0 :        3  6.993e-01   35.0  0.000e+00  2.331e-01  4.800e+10  6.864e+10 B/sec
Rank     1 :        3  6.983e-01   34.9  1.083e-03  2.328e-01  4.800e+10  6.874e+10 B/sec
Label  First section
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     0 :        1  2.306e-01   11.5  9.871e-04  2.306e-01  4.000e+09  1.734e+10 Flops
Rank     1 :        1  2.316e-01   11.6  0.000e+00  2.316e-01  4.000e+09  1.727e+10 Flops
```

京コンピュータ: test2の実行結果例

基本レポート：環境変数 HWPC_CHOOSERの指定がないため計算量自己申告モードだが、計算量を引数で与えていない（あるいは0と指定）している。

```
# PMlib Basic Report -----------------------------------------------------

      Timing Statistics Report from PMlib version 5.0.4
      Linked PMlib supports: MPI, OpenMP, HWPC, no-OTF
      Host name : g05-040
      Date      : 2016/06/22 : 01:31:43
      Mr. Bean
      Parallel Mode:   Hybrid (2 processes x 4 threads)
      The environment variable HWPC_CHOOSER is not provided. No HWPC report.

      Total execution time            = 9.388940e-01 [sec]
      Total time of measured sections = 9.348356e-01 [sec]

      Exclusive sections statistics per process and total job.
      Inclusive sections are marked with (*)

      Section         |    call  |        accumulated time[sec]           | [user defined counter values ]
      Label           |          |      avr   avr[%]      sdv   avr/call  |      avr       sdv    speed
      ----------------+----------+----------------------------------------+-----------------------------
      First location  :        1   6.967e-01  74.53  3.25e-03  6.967e-01    0.000e+00  0.00e+00   0.00 Mflops
      Second location :        1   2.349e-01  25.13  9.45e-04  2.349e-01    0.000e+00  0.00e+00   0.00 Mflops
      ----------------+----------+----------------------------------------+-----------------------------
      Sections per process         9.317e-01     -Exclusive CALC sections-  0.000e+00              0.00 Mflops
      ----------------+----------+----------------------------------------+-----------------------------
      Sections total job           9.317e-01     -Exclusive CALC sections-  0.000e+00              0.00 Mflops
```

京コンピュータ: test2の実行結果例

詳細レポート：各測定区間毎に全MPIランクのレポート

```
# PMlib Process Report --- Elapsed time for individual MPI ranks ------

Label  First location
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     0 :        1  6.990e-01   74.8  0.000e+00  6.990e-01  0.000e+00  0.000e+00 Flops
Rank     1 :        1  6.944e-01   74.3  4.600e-03  6.944e-01  0.000e+00  0.000e+00 Flops
Label  Second location
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     0 :        1  2.356e-01   25.2  0.000e+00  2.356e-01  0.000e+00  0.000e+00 Flops
Rank     1 :        1  2.343e-01   25.1  1.336e-03  2.343e-01  0.000e+00  0.000e+00 Flops
```

京コンピュータ: test3の実行結果例

基本レポート、詳細レポートの他、プロセスグループ毎の詳細レポートを出力

```
# PMlib Basic Report ------------------------------------------------------ (省略)
# PMlib Process Report --- Elapsed time for individual MPI ranks ----------- (省略)

# PMlib Process Group [    1] Elapsed time for individual MPI ranks --------

Label  2nd section
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     0 :        1  5.128e-01   60.8  0.000e+00  5.128e-01  0.000e+00  0.000e+00 Flops
Label  1st section
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     0 :        1  2.333e-01   27.6  0.000e+00  2.333e-01  0.000e+00  0.000e+00 Flops


# PMlib Process Group [    2] Elapsed time for individual MPI ranks --------

Label  2ndModified STREAM TRIAD, num_threads=4, array size= 50000000
Function      Rate (MB/s)   Avg time     Min time     Max time
Triad:    35941.1650       0.0558       0.0334       0.0914
 section
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     1 :        1  6.976e-01   82.7  0.000e+00  6.976e-01  0.000e+00  0.000e+00 Flops
Label  1st section
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     1 :        1  2.326e-01   27.6  0.000e+00  2.326e-01  0.000e+00  0.000e+00 Flops
```

京コンピュータ: test4の実行結果例

基本レポート、詳細レポートを出力

```
# PMlib Basic Report -------------------------------------------------------

      Timing Statistics Report from PMlib version 5.0.4
      Linked PMlib supports: MPI, OpenMP, HWPC, no-OTF
      Host name : g05-040
      Date      : 2016/06/22 : 01:39:46
      Fortran API
      Parallel Mode:   Hybrid (2 processes x 4 threads)
      The environment variable HWPC_CHOOSER is not provided. No HWPC report.

      Total execution time            = 1.318232e+01 [sec]
      Total time of measured sections = 1.306007e+01 [sec]

      Exclusive sections statistics per process and total job.
      Inclusive sections are marked with (*)

      Section           |    call  |        accumulated time[sec]           | [user defined counter values ]
      Label             |          |      avr   avr[%]      sdv   avr/call  |      avr       sdv   speed
      ------------------+----------+----------------------------------------+---------------------------
      Second section(*) :        1   1.282e+01  98.17  1.57e-01  1.282e+01    1.200e+10  0.00e+00 935.95 Mflops(*)
      Subsection X      :        3   5.733e+00  43.90  1.02e-01  1.911e+00    2.400e+10  0.00e+00   4.19 GB/sec
      Subsection Y      :        3   5.703e+00  43.67  7.93e-02  1.901e+00    6.000e+09  0.00e+00   1.05 Gflops
      First section     :        1   1.464e-03   0.01  4.21e-06  1.464e-03    4.000e+06  0.00e+00   2.73 Gflops
      ------------------+----------+----------------------------------------+---------------------------
      Sections per process          5.705e+00     -Exclusive CALC sections-  6.004e+09             1.05 Gflops
      Sections per process          5.733e+00     -Exclusive COMM sections-  2.400e+10             4.19 GB/sec
      ------------------+----------+----------------------------------------+---------------------------
      Sections total job            5.705e+00     -Exclusive CALC sections-  1.201e+10             2.10 Gflops
      Sections total job            5.733e+00     -Exclusive COMM sections-  4.800e+10             8.37 GB/sec

# PMlib Process Report --- Elapsed time for individual MPI ranks ----------- (省略)
```

京コンピュータ: test5の実行結果例

基本+詳細+MPI_Comm_splitでコミュニケータを分割したプロセス毎のレポート

```
# PMlib Basic Report ------------------------------------------------------ (省略)
# PMlib Process Report --- Elapsed time for individual MPI ranks ----------- (省略)

# PMlib Process Group [    0] Elapsed time for individual MPI ranks --------

Label  section-2
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     0 :        1  6.957e-01  114.0  0.000e+00  6.957e-01  0.000e+00  0.000e+00 Flops
Label  section-1
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     0 :        1  3.541e-03    0.6  0.000e+00  3.541e-03  0.000e+00  0.000e+00 Flops

# PMlib Process Group [    1] Elapsed time for individual MPI ranks --------

Label  section-2
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     1 :        1  5.110e-01   83.7  0.000e+00  5.110e-01  0.000e+00  0.000e+00 Flops
Label  section-1
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     1 :        1  1.822e-03    0.3  0.000e+00  1.822e-03  0.000e+00  0.000e+00 Flops
```

HWPCを利用した計算量の自動測定

- 環境変数HWPC_CHOOSERにFLOPSを指定

```
K$  cat x.run-test1.sh
#!/bin/bash
#PJM -N MYTEST1
#PJM --rsc-list "elapse=1:00:00"
#PJM --rsc-list "node=1"
#PJM --mpi "proc=2”
#PJM -j
#PJM -S
# stage io files
#PJM --stg-transfiles all
#PJM --mpi "use-rankdir"
#PJM --stgin-basedir "/home/ra000004/a03155/pmlib/PMlib/BUILD_DIR/example"
#PJM --stgin "rank=* test1/test1 %r:./test1”
source /work/system/Env_base
/opt/FJSVXosPA/bin/xospastop
export OMP_NUM_THREADS=4  NPROCS=2
export HWPC_CHOOSER=FLOPS
mpiexec -n ${NPROCS} ./test1

K$  pjsub  x.run-test1.sh
```

京Test1：HWPC_CHOOSERにFLOPSを指定

基本レポート：計算量の自動測定

```
# PMlib Basic Report -----------------------------------------------------

      Timing Statistics Report from PMlib version 5.0.4
      Linked PMlib supports: MPI, OpenMP, HWPC, no-OTF
      Host name : g05-040
      Date      : 2016/06/22 : 01:53:20
      Mrs. Kobe
      Parallel Mode:   Hybrid (2 processes x 4 threads)
      The environment variable HWPC_CHOOSER=FLOPS is provided.

      Total execution time            = 2.005677e+00 [sec]
      Total time of measured sections = 1.996694e+00 [sec]

      Exclusive sections statistics per process and total job.
      Inclusive sections are marked with (*)

      Section          |    call  |          accumulated time[sec]                | [hardware counter by ce counts]
      Label            |                  avr   avr[%]      sdv    avr/call  |      avr       sdv    speed
      -----------------+-----------------------------------------------------+---------------------------
      Second section(*) :        1   1.733e+00  86.77  9.56e-03  1.733e+00    4.603e+09  7.07e-01   2.66 Gflops(*)
      Subsection X      :        3   6.975e-01  34.94  1.18e-03  2.325e-01    1.438e+10  2.12e+00  20.61 Gflops
      Subsection Y      :        3   6.962e-01  34.87  1.60e-03  2.321e-01    1.381e+10  2.12e+00  19.83 Gflops
      First section     :        1   2.309e-01  11.56  1.50e-05  2.309e-01    4.090e+09  4.77e-07  17.71 Gflops
      -----------------+-----------------------------------------------------+---------------------------
      Sections per process          1.625e+00     -Exclusive CALC sections-   3.228e+10           19.87 Gflops
      -----------------+-----------------------------------------------------+---------------------------
      Sections total job            1.625e+00     -Exclusive CALC sections-   6.455e+10           39.73 Gflops
```

京Test1：HWPC_CHOOSERにFLOPSを指定

詳細レポート（計算量の自動測定）：プロセス毎の詳細レポート、HWPCレポート

```
# PMlib Process Report --- Elapsed time for individual MPI ranks ------

Label  Subsection X
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     0 :        3  6.984e-01   35.0  0.000e+00  2.328e-01  1.438e+10  2.059e+10 Flops (HWPC)
Rank     1 :        3  6.967e-01   34.9  1.675e-03  2.322e-01  1.438e+10  2.064e+10 Flops (HWPC)
Label  Subsection Y
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     0 :        3  6.974e-01   34.9  0.000e+00  2.325e-01  1.381e+10  1.980e+10 Flops (HWPC)
Rank     1 :        3  6.951e-01   34.8  2.259e-03  2.317e-01  1.381e+10  1.986e+10 Flops (HWPC)
Label  First section
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     0 :        1  2.309e-01   11.6  2.122e-05  2.309e-01  4.090e+09  1.771e+10 Flops (HWPC)
Rank     1 :        1  2.309e-01   11.6  0.000e+00  2.309e-01  4.090e+09  1.771e+10 Flops (HWPC)

# PMlib hardware performance counter (HWPC) Report -------------------------
Label   Subsection X
Header  ID :     FP_OPS    [Flops]
Rank     0 :  1.438e+10  2.059e+10
Rank     1 :  1.438e+10  2.064e+10
Label   Subsection Y
Header  ID :     FP_OPS    [Flops]
Rank     0 :  1.381e+10  1.980e+10
Rank     1 :  1.381e+10  1.986e+10
Label   First section
Header  ID :     FP_OPS    [Flops]
Rank     0 :  4.090e+09  1.771e+10
Rank     1 :  4.090e+09  1.771e+10
```

京Test1：HWPCレポートの記号

printDetail()関数へのlegend引数指定で表示（表示項目はシステム毎に異なる）

```
Detected CPU architecture:
       Sun
       Fujitsu SPARC64 VIIIfx
       The available PMlib HWPC events for this CPU are shown below.
       The values for each process as the sum of threads.
   HWPC events legend:
       FP_OPS: floating point operations
       VEC_INS: vector instructions
       FMA_INS: Fused Multiply-and-Add instructions
       LD_INS: memory load instructions
       SR_INS: memory store instructions
       L1_TCM: level 1 cache miss
       L2_TCM: level 2 cache miss (by demand and by prefetch)
       L2_WB_DM: level 2 cache miss by demand with writeback request
       L2_WB_PF: level 2 cache miss by prefetch with writeback request
       TOT_CYC: total cycles
       MEM_SCY: Cycles Stalled Waiting for memory accesses
       STL_ICY: Cycles with no instruction issue
       TOT_INS: total instructions
       FP_INS: floating point instructions
   Derived statistics:
       [GFlops]: floating point operations per nano seconds (10^-9)
       [Mem GB/s]: memory bandwidth in load+store GB/s
       [L1$ %]: Level 1 cache hit percentage
       [LL$ %]: Last Level cache hit percentage
```

京Test2：HWPC_CHOOSERにFLOPSを指定

基本レポート：計算量の自動測定

```
# PMlib Basic Report -----------------------------------------------------

      Timing Statistics Report from PMlib version 5.0.4
      Linked PMlib supports: MPI, OpenMP, HWPC, no-OTF
      Host name : g05-040
      Date      : 2016/06/22 : 01:56:47
      Mr. Bean
      Parallel Mode:   Hybrid (2 processes x 4 threads)
      The environment variable HWPC_CHOOSER=FLOPS is provided.

      Total execution time            = 9.402618e-01 [sec]
      Total time of measured sections = 9.368410e-01 [sec]

      Exclusive sections statistics per process and total job.
      Inclusive sections are marked with (*)

      Section         |    call  |        accumulated time[sec]                | [hardware counter byte counts]
      Label           |          |      avr   avr[%]      sdv    avr/call  |      avr       sdv    speed
      ----------------+----------+---------------------------------------------+-------------------------
      First location  :        1   7.002e-01  74.74  1.35e-03  7.002e-01    1.216e+10  0.00e+00  17.36 Gflops
      Second location :        1   2.327e-01  24.84  1.10e-03  2.327e-01    4.033e+09  0.00e+00  17.33 Gflops
      ----------------+----------+---------------------------------------------+-------------------------
      Sections per process        9.329e-01     -Exclusive CALC sections-   1.619e+10            17.35 Gflops
      ----------------+----------+---------------------------------------------+-------------------------
      Sections total job          9.329e-01     -Exclusive CALC sections-   3.238e+10            34.71 Gflops
```

京Test1：HWPC_CHOOSERにBANDWIDTHを指定

```
# PMlib Basic Report -------------------------------------------------------

      Timing Statistics Report from PMlib version 5.0.4
      Linked PMlib supports: MPI, OpenMP, HWPC, no-OTF
      Host name : g05-040
      Date      : 2016/06/22 : 01:58:50
      Mrs. Kobe
      Parallel Mode:   Hybrid (2 processes x 4 threads)
      The environment variable HWPC_CHOOSER=BANDWIDTH is provided.

      Total execution time            = 2.009118e+00 [sec]
      Total time of measured sections = 2.000287e+00 [sec]

      Exclusive sections statistics per process and total job.
      Inclusive sections are marked with (*)

      Section           |    call  |        accumulated time[sec]           | [hardware counter flop counts]
      Label             |          |      avr   avr[%]      sdv   avr/call  |      avr       sdv   speed
      ------------------+----------+----------------------------------------+-------------------------------
      Second section(*) :        1   1.736e+00  86.78  9.59e-03  1.736e+00    5.274e+09  6.38e+07   3.04 GB/sec(*)
      Subsection Y      :        3   6.998e-01  34.98  1.21e-03  2.333e-01    1.588e+10  2.72e+08  22.69 GB/sec
      Subsection X      :        3   6.963e-01  34.81  9.91e-04  2.321e-01    1.561e+10  1.90e+08  22.42 GB/sec
      First section     :        1   2.313e-01  11.57  1.34e-04  2.313e-01    4.797e+09  2.57e+08  20.74 GB/sec
      ------------------+----------+----------------------------------------+-------------------------------
      Sections per process          1.627e+00     -Exclusive COMM sections-  3.629e+10           22.30 GB/sec
      ------------------+----------+----------------------------------------+-------------------------------
      Sections total job            1.627e+00     -Exclusive COMM sections-  7.258e+10           44.59 GB/sec
```

京Test1 : HWPC_CHOOSERにBANDWIDTHを指定

```
# PMlib Process Report --- Elapsed time for individual MPI ranks ------

Label  Subsection Y
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     0 :        3  7.007e-01   35.0  0.000e+00  2.336e-01  1.607e+10  2.294e+10 B/sec (HWPC)
Rank     1 :        3  6.989e-01   34.9  1.718e-03  2.330e-01  1.569e+10  2.245e+10 B/sec (HWPC)
Label  Subsection X
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     0 :        3  6.970e-01   34.8  0.000e+00  2.323e-01  1.574e+10  2.259e+10 B/sec (HWPC)
Rank     1 :        3  6.956e-01   34.8  1.402e-03  2.319e-01  1.548e+10  2.225e+10 B/sec (HWPC)
Label  First section
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   counter     speed
Rank     0 :        1  2.312e-01   11.6  1.888e-04  2.312e-01  4.616e+09  1.996e+10 B/sec (HWPC)
Rank     1 :        1  2.314e-01   11.6  0.000e+00  2.314e-01  4.978e+09  2.151e+10 B/sec (HWPC)

# PMlib hardware performance counter (HWPC) Report -------------------------
Label   Subsection Y
Header  ID :     L2_TCM   L2_WB_DM   L2_WB_PF   [HW B/s]
Rank     0 :  1.226e+08  6.057e+03  2.921e+06  2.294e+10
Rank     1 :  1.197e+08  6.342e+03  2.837e+06  2.245e+10
Label   Subsection X
Header  ID :     L2_TCM   L2_WB_DM   L2_WB_PF   [HW B/s]
Rank     0 :  1.191e+08  1.137e+04  3.844e+06  2.259e+10
Rank     1 :  1.175e+08  7.926e+03  3.359e+06  2.225e+10
Label   First section
Header  ID :     L2_TCM   L2_WB_DM   L2_WB_PF   [HW B/s]
Rank     0 :  3.487e+07  6.986e+03  1.179e+06  1.996e+10
Rank     1 :  3.851e+07  8.730e+02  3.850e+05  2.151e+10
```

京Test1：HWPC_CHOOSERにCYCLEを指定

```
# PMlib hardware performance counter (HWPC) Report -------------------------
Label   Subsection Y
Header  ID :    TOT_CYC    TOT_INS     LD_INS     SR_INS
Rank     0 :  5.953e+09  1.267e+10  6.036e+09  1.051e+08
Rank     1 :  5.907e+09  1.267e+10  6.036e+09  1.051e+08
Label   Subsection X
Header  ID :    TOT_CYC    TOT_INS     LD_INS     SR_INS
Rank     0 :  6.063e+09  1.292e+10  6.046e+09  1.351e+08
Rank     1 :  6.025e+09  1.292e+10  6.046e+09  1.351e+08
Label   First section
Header  ID :    TOT_CYC    TOT_INS     LD_INS     SR_INS
Rank     0 :  1.862e+09  3.997e+09  2.003e+09  8.019e+06
Rank     1 :  1.863e+09  3.997e+09  2.003e+09  8.018e+06
```

京Test1 : HWPC_CHOOSERにCACHEを指定

```
# PMlib hardware performance counter (HWPC) Report -------------------------
Label   Subsection Y
Header  ID :     L1_TCM     L2_TCM
Rank     0 :  2.460e+08  1.224e+08
Rank     1 :  2.460e+08  1.177e+08
Label   Subsection X
Header  ID :     L1_TCM     L2_TCM
Rank     0 :  2.470e+08  1.253e+08
Rank     1 :  2.470e+08  1.160e+08
Label   First section
Header  ID :     L1_TCM     L2_TCM
Rank     0 :  8.113e+07  3.683e+07
Rank     1 :  8.113e+07  3.781e+07
```

Intel Xeonクラスタでの実習
PMlibのインストール

PMlibのインストール　Intel 環境

- 京コンピュータと同様の手順だが、configureのオプションが異なる。
- 以下の例はIntelコンパイラ、Intel MPIの組み合わせでmakeする場合

```
$   cat  x.make-intel-impi.sh
#! /bin/bash
module load intel impi papi/intel   # moduleコマンドについては次ページを参照
SRC_DIR=${HOME}/pmlib/PMlib
cd ${SRC_DIR}; if [ $? != 0 ] ; then echo '@@@ Directory error @@@'; exit; fi
autoreconf –i     # 初回のみ  autoreconf の実行が必要な場合がある。

cd ${SRC_DIR}/BUILD_DIR; if [ $? != 0 ] ; then echo '@@@ Directory error @@@'; exit; fi
CFLAGS="-std=c99 -openmp"
FCFLAGS="-fpp -openmp "
CXXFLAGS="-openmp ”
INSTALL_DIR=${HOME}/pmlib/install_develop

../configure \
    CXX=mpiicpc CC=mpiicc FC=mpiifort \
    CFLAGS="${CFLAGS}" CXXFLAGS="${CXXFLAGS}" FCFLAGS="${FCFLAGS}" \
    --with-comp=INTEL  --with-impi=${I_MPI_ROOT} \
    --with-papi=${PAPI_DIR}   --with-example=yes  -prefix=${INSTALL_DIR}

make
make install

$  ./x.make-intel-impi.sh
```

PMlibのインストール　Intel 環境

- 前ページの例で第2行目のmoduleコマンド

```
module load  intel  impi papi/intel
```

- は以下のコマンド群と同様な効果がある。もしmoduleコマンドが設定されていない場合は、Intelコンパイラ、Intel MPI、PAPIの実際のディレクトリパスを確認の上、この行を以下のコマンド群に書き換えてmakeする。

```
#   module load intel
INTEL_DIR=/usr/local/intel/composer_xe_2013
source ${INTEL_DIR}/bin/compilervars.sh intel64

#   module load impi
export I_MPI_ROOT=/usr/local/intel/impi/4.1.0.024
source ${I_MPI_ROOT}/bin64/mpivars.sh
export I_MPI_F90=ifort
export I_MPI_F77=ifort
export I_MPI_CC=icc
export I_MPI_CXX=icpc

#   module load papi/intel
PAPI_ROOT=/usr/local/papi/papi-5.3.2/intel
PAPI_DIR=${PAPI_ROOT}
export LDFLAGS="-L${PAPI_ROOT}/lib -lpapi -lpfm"
export INCLUDES="-I{PAPI_ROOT}/include"
export LD_LIBRARY_PATH=${PAPI_ROOT}/lib:${LD_LIBRARY_PATH}
```

PMlibのインストール　GNU 環境

- 京コンピュータと同様の手順だが、configureのオプションが異なる。
- 以下の例はGNUコンパイラ、OpenMPIの組み合わせでmakeする場合

```
$   cat  x.make-gnu-openmpi.sh
#! /bin/bash
module load  openmpi/gnu  papi/gnu   # moduleコマンドについては次ページを参照
SRC_DIR=${HOME}/pmlib/PMlib
cd ${SRC_DIR}; if [ $? != 0 ] ; then echo '@@@ Directory error @@@'; exit; fi
autoreconf –i     # 初回のみ  autoreconf の実行が必要な場合がある。

cd ${SRC_DIR}/BUILD_DIR; if [ $? != 0 ] ; then echo '@@@ Directory error @@@'; exit; fi
CFLAGS="-O3 -fopenmp ”
FCFLAGS="-cpp -O3 -fopenmp "
CXXFLAGS="-O3 -fopenmp ”
INSTALL_DIR=${HOME}/pmlib/install_gnu

../configure \
    CXX=mpicxx CC=mpicc FC=mpif90 \
    CFLAGS="${CFLAGS}"  CXXFLAGS="${CXXFLAGS}"  FCFLAGS="${FCFLAGS}" \
    --with-comp=GNU  --with-ompi=${MPI_DIR}  \
    --with-papi=${PAPI_DIR}  --with-example=yes  -prefix=${INSTALL_DIR}

make
make install

$  ./x.make-gnu-openmpi.sh
```

PMlibのインストール　GNU 環境

- 前ページの例でmoduleコマンドの行

```
module load  openmpi/gnu  papi/gnu
```

- は以下のコマンド群と同じ効果である。もしmoduleコマンドが設定されていない場合は、OpenMPIやPAPIの実際のディレクトリパスを確認の上、この行をコマンド群に書き換えてmakeする。

```
export  FC=gfortran
export  CC=gcc
export  CXX=g++
export  HYDRA_BOOTSTRAP=ssh
export  HYDRA_BOOTSTRAP_EXEC=/usr/bin/ssh
OPENMPI_DIR=/usr/local/openmpi/openmpi-1.8.7-gnu
PAPI_ROOT=/usr/local/papi/papi-5.3.2/gnu
LDFLAGS="-L${PAPI_ROOT}/lib -lpapi -lpfm"
INCLUDES="-I{PAPI_ROOT}/include"

export  PATH=${OPENMPI_DIR}/bin:${PAPI_ROOT}/bin:${PATH}
export  LD_LIBRARY_PATH=${OPENMPI_DIR}/lib:${PAPI_ROOT}/lib:${LD_LIBRARY_PATH}
MPI_DIR=${OPENMPI_DIR}
PAPI_DIR=${PAPI_ROOT}
```

Intel Xeonクラスタでの実習
例題プログラムの実行
（以降の出力例はPMlib-4.0の場合）

PMlib例題プログラムの実行 Intel Xeon

- makeされたexample/test[1-5]プログラムを計算ノード上で実行する
- バッチジョブを投入・実行する。
- 下の例はtest1プログラムでの例（test2-test5も同様）
  - 環境変数 HWPC_CHOOSERの指定がないため計算量自己申告モード

```
#!/bin/bash
#BSUB -J PMLIB-EXAMPLE-INTEL
#BSUB -o PMLIB-EXAMPLE-INTEL-%J
#BSUB -n 4
#BSUB -R "span[ptile=1]"
#BSUB –x
module load intel impi papi/intel pmlib/intel

BUILD_DIR=${HOME}/pmlib/PMlib/BUILD_DIR
WKDIR=/media/dali/data1/mikami/check_pmlib
cd $WKDIR; if [ $? != 0 ] ; then echo '@@@ Directory error @@@'; exit; fi

NPROCS=4
export OMP_NUM_THREADS=8
mpirun -np ${NPROCS} ${BUILD_DIR}/example/test1/test1
```

Intel Xeon : test1の実行結果例

基本レポート：環境変数 HWPC_CHOOSERの指定なし
→経過時間と自己申告計算量（関数への引数で明示的に与えた式・値を評価）

```
# PMlib Basic Report -----------------------------------------------------

    Timing Statistics Report from PMlib version 4.1.4
    Linked PMlib supports: MPI, OpenMP, HWPC
    Host name : vsp20
    Date      : 2015/10/27 : 16:23:50
    Mr. Bean
    Parallel Mode:   Hybrid (4 processes x 8 threads)
    The environment variable HWPC_CHOOSER is not provided. No HWPC report.

    Total execution time            = 2.614012e-01 [sec]
    Total time of measured sections = 2.590960e-01 [sec]

    Exclusive Sections statistics per process and total job.

    Section         |    call          accumulated time[sec]                |  [flop counts or byte counts ]
    Label           |                  avr    avr[%]      sdv    avr/call  |       avr        sdv    speed
    ----------------+-----------------------------------------------------+-----------------------------
    First location  :         3   1.569e-01   60.56   5.38e-04   5.230e-02    0.000e+00   0.00e+00    0.00 Mflops
    Third location  :         1   5.111e-02   19.73   1.41e-04   5.111e-02    1.601e+10   0.00e+00  313.23 GB/sec
    Second location :         1   5.109e-02   19.72   1.14e-04   5.109e-02    4.000e+09   0.00e+00   78.29 Gflops
    ----------------+-----------------------------------------------------+-----------------------------
    Sections per process          2.080e-01                                4.000e+09             19.23 Gflops
    Sections per process          5.111e-02                                1.601e+10            313.23 GB/sec
    ----------------+-----------------------------------------------------+-----------------------------
    Sections total job            2.080e-01                                1.600e+10             76.93 Gflops
    Sections total job            5.111e-02                                6.403e+10              1.25 TB/sec
```

Intel Xeon : test1の実行結果例

詳細レポート：環境変数 HWPC_CHOOSERを設定しないで実行した場合の例

```
# PMlib Process Report --- Elapsed time for individual MPI ranks ------

Label  First location
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   flop|msg    speed
Rank     0 :        3  1.572e-01   60.7  2.363e-04  5.241e-02  0.000e+00  0.000e+00 Flops
Rank     1 :        3  1.563e-01   60.3  1.139e-03  5.211e-02  0.000e+00  0.000e+00 Flops
Rank     2 :        3  1.575e-01   60.8  0.000e+00  5.249e-02  0.000e+00  0.000e+00 Flops
Rank     3 :        3  1.566e-01   60.4  8.991e-04  5.219e-02  0.000e+00  0.000e+00 Flops
Label  Third location
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   flop|msg    speed
Rank     0 :        1  5.104e-02   19.7  2.699e-04  5.104e-02  1.601e+10  3.136e+11 Bytes/sec
Rank     1 :        1  5.107e-02   19.7  2.420e-04  5.107e-02  1.601e+10  3.134e+11 Bytes/sec
Rank     2 :        1  5.131e-02   19.8  0.000e+00  5.131e-02  1.601e+10  3.120e+11 Bytes/sec
Rank     3 :        1  5.100e-02   19.7  3.159e-04  5.100e-02  1.601e+10  3.139e+11 Bytes/sec
Label  Second location
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   flop|msg    speed
Rank     0 :        1  5.105e-02   19.7  2.139e-04  5.105e-02  4.000e+09  7.836e+10 Flops
Rank     1 :        1  5.104e-02   19.7  2.170e-04  5.104e-02  4.000e+09  7.836e+10 Flops
Rank     2 :        1  5.126e-02   19.8  0.000e+00  5.126e-02  4.000e+09  7.803e+10 Flops
Rank     3 :        1  5.102e-02   19.7  2.460e-04  5.102e-02  4.000e+09  7.841e+10 Flops
```

Intel Xeon : test2の実行結果例

基本レポート：環境変数 HWPC_CHOOSERの指定がないため計算量自己申告モード
自己申告モードで計算量を引数で与えないと0と解釈され、時間情報だけが評価される

```
# PMlib Basic Report -----------------------------------------------------

    Timing Statistics Report from PMlib version 4.1.4
    Linked PMlib supports: MPI, OpenMP, HWPC
    Host name : vsp21
    Date      : 2015/10/27 : 19:59:20
    Mr. Bean
    Parallel Mode:   Hybrid (4 processes x 8 threads)
    The environment variable HWPC_CHOOSER is not provided. No HWPC report.

    Total execution time            = 2.094159e-01 [sec]
    Total time of measured sections = 2.076831e-01 [sec]

    Exclusive Sections statistics per process and total job.

    Section         |    call  |        accumulated time[sec]           | [flop counts or byte counts ]
    Label           |          |       avr    avr[%]      sdv   avr/call |       avr       sdv   speed
    ----------------+----------+----------------------------------------+---------------------------
    First location  :        1   1.567e-01   75.45  4.12e-04  1.567e-01    0.000e+00  0.00e+00   0.00 Mflops
    Second location :        1   5.099e-02   24.55  1.65e-04  5.099e-02    0.000e+00  0.00e+00   0.00 Mflops
    ----------------+----------+----------------------------------------+---------------------------
    Sections per process         2.077e-01                                0.000e+00             0.00 Mflops
    ----------------+----------+----------------------------------------+---------------------------
    Sections total job           2.077e-01                                0.000e+00             0.00 Mflops
```

Intel Xeon : test2の実行結果例

詳細レポート：各測定区間毎に全MPIランクのレポート

```
# PMlib Process Report --- Elapsed time for individual MPI ranks ------

Label  First location
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   flop|msg    speed
Rank     0 :        1  1.565e-01   75.4  7.432e-04  1.565e-01  0.000e+00  0.000e+00 Flops
Rank     1 :        1  1.566e-01   75.4  6.323e-04  1.566e-01  0.000e+00  0.000e+00 Flops
Rank     2 :        1  1.563e-01   75.3  9.592e-04  1.563e-01  0.000e+00  0.000e+00 Flops
Rank     3 :        1  1.573e-01   75.7  0.000e+00  1.573e-01  0.000e+00  0.000e+00 Flops
Label  Second location
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   flop|msg    speed
Rank     0 :        1  5.082e-02   24.5  3.271e-04  5.082e-02  0.000e+00  0.000e+00 Flops
Rank     1 :        1  5.087e-02   24.5  2.720e-04  5.087e-02  0.000e+00  0.000e+00 Flops
Rank     2 :        1  5.111e-02   24.6  3.505e-05  5.111e-02  0.000e+00  0.000e+00 Flops
Rank     3 :        1  5.114e-02   24.6  0.000e+00  5.114e-02  0.000e+00  0.000e+00 Flops
```

Intel Xeon : test3の実行結果例

基本レポート、詳細レポートの他、プロセスグループ毎の詳細レポートを出力

```
# PMlib Basic Report ------------------------------------------------------ (省略)
# PMlib Process Report --- Elapsed time for individual MPI ranks ----------- (省略)

# PMlib Process Group [    1] Elapsed time for individual MPI ranks --------

Label  2nd section
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   flop|msg    speed
Rank     0 :        1  2.043e-01   68.5  4.163e-04  2.043e-01  0.000e+00  0.000e+00 Flops
Rank     1 :        1  2.048e-01   68.7  0.000e+00  2.048e-01  0.000e+00  0.000e+00 Flops
Label  1st section
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   flop|msg    speed
Rank     0 :        1  5.444e-02   18.3  0.000e+00  5.444e-02  0.000e+00  0.000e+00 Flops
Rank     1 :        1  5.247e-02   17.6  1.966e-03  5.247e-02  0.000e+00  0.000e+00 Flops

# PMlib Process Group [    2] Elapsed time for individual MPI ranks --------

Label  2nd section
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   flop|msg    speed
Rank     2 :        1  2.514e-01   84.3  6.453e-02  2.514e-01  0.000e+00  0.000e+00 Flops
Rank     3 :        1  3.160e-01  106.0  0.000e+00  3.160e-01  0.000e+00  0.000e+00 Flops
Label  1st section
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   flop|msg    speed
Rank     2 :        1  5.500e-02   18.4  0.000e+00  5.500e-02  0.000e+00  0.000e+00 Flops
Rank     3 :        1  5.409e-02   18.1  9.141e-04  5.409e-02  0.000e+00  0.000e+00 Flops
```

Intel Xeon : test4の実行結果例

FortranプログラムからのPMlib利用。
基本レポート（詳細レポート、HWPCレポートも同様）

```
# PMlib Basic Report -----------------------------------------------------

    Timing Statistics Report from PMlib version 4.1.4
    Linked PMlib supports: MPI, OpenMP, HWPC
    Host name : vsp21
    Date      : 2015/10/27 : 19:59:26
    user
    Parallel Mode:   Hybrid (4 processes x 8 threads)
    The environment variable HWPC_CHOOSER is not provided. No HWPC report.

    Total execution time            = 2.325020e-01 [sec]
    Total time of measured sections = 2.335144e-01 [sec]

    Exclusive Sections statistics per process and total job.

    Section   |    call  |        accumulated time[sec]           | [flop counts or byte counts ]
    Label     |          |      avr   avr[%]      sdv   avr/call  |      avr       sdv   speed
    ----------+----------+----------------------------------------+--------------------------
    2-submtxm :        3   2.311e-01  98.98  6.63e-03  7.704e-02    0.000e+00  0.00e+00   0.00 MB/sec
    1-subinit :        1   2.391e-03   1.02  3.47e-05  2.391e-03    0.000e+00  0.00e+00   0.00 MB/sec
    ----------+----------+----------------------------------------+--------------------------
    Sections per process   2.335e-01                                 0.000e+00             0.00 MB/sec
    ----------+----------+----------------------------------------+--------------------------
    Sections total job     2.335e-01                                 0.000e+00             0.00 MB/sec
```

Intel Xeon : test5の実行結果例

基本レポート、詳細レポート、＋PMlibが内部でグループ化したプロセス毎のレポート

```
# PMlib Basic Report ------------------------------------------------------ (省略)
# PMlib Process Report --- Elapsed time for individual MPI ranks ----------- (省略)

# PMlib Process Group [    0] Elapsed time for individual MPI ranks --------

Label  section-2
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   flop|msg    speed
Rank     0 :        1  2.507e-01  109.8  0.000e+00  2.507e-01  0.000e+00  0.000e+00 Flops
Rank     1 :        1  2.501e-01  109.5  6.680e-04  2.501e-01  0.000e+00  0.000e+00 Flops
Label  section-1
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   flop|msg    speed
Rank     0 :        1  1.833e-03    0.8  9.060e-06  1.833e-03  0.000e+00  0.000e+00 Flops
Rank     1 :        1  1.842e-03    0.8  0.000e+00  1.842e-03  0.000e+00  0.000e+00 Flops

# PMlib Process Group [    1] Elapsed time for individual MPI ranks --------

Label  section-2
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   flop|msg    speed
Rank     2 :        1  2.030e-01   88.9  0.000e+00  2.030e-01  0.000e+00  0.000e+00 Flops
Rank     3 :        1  2.022e-01   88.5  7.873e-04  2.022e-01  0.000e+00  0.000e+00 Flops
Label  section-1
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   flop|msg    speed
Rank     2 :        1  1.950e-03    0.9  0.000e+00  1.950e-03  0.000e+00  0.000e+00 Flops
Rank     3 :        1  1.821e-03    0.8  1.287e-04  1.821e-03  0.000e+00  0.000e+00 Flops
```

HWPCを利用した計算量の自動測定 Intel Xeon

- test1のバッチジョブ実行例
- 計算量の自動測定モード（環境変数 HWPC_CHOOSERで指定）

```
#!/bin/bash
#BSUB -J PMLIB-EXAMPLE-INTEL
#BSUB -o PMLIB-EXAMPLE-INTEL-%J
#BSUB -n 4
#BSUB -R "span[ptile=1]"
#BSUB –x
module load intel impi papi/intel pmlib/intel

BUILD_DIR=${HOME}/pmlib/PMlib/BUILD_DIR
WKDIR=/media/dali/data1/mikami/check_pmlib
cd $WKDIR; if [ $? != 0 ] ; then echo '@@@ Directory error @@@'; exit; fi

NPROCS=4
export OMP_NUM_THREADS=8
export HWPC_CHOOSER=FLOPS
mpirun -np ${NPROCS} ${BUILD_DIR}/example/test1/test1
```

Intel Xeon Test1 : HWPC_CHOOSERにFLOPSを指定

基本レポート:計算量の自動測定

```
# PMlib Basic Report -------------------------------------------------------

    Timing Statistics Report from PMlib version 4.1.4
    Linked PMlib supports: MPI, OpenMP, HWPC
    Host name : vsp21
    Date      : 2015/10/27 : 19:59:31
    Mr. Bean
    Parallel Mode:   Hybrid (4 processes x 8 threads)
    The environment variable HWPC_CHOOSER=FLOPS is provided.

    Total execution time            = 2.612011e-01 [sec]
    Total time of measured sections = 2.590463e-01 [sec]

    Exclusive Sections statistics per process and total job.

    Section         |    call  |       accumulated time[sec]           | [flop counts or byte counts ]
    Label           |          |     avr    avr[%]      sdv   avr/call |      avr       sdv   speed
    ----------------+----------+---------------------------------------+-----------------------------
    First location  :        3   1.569e-01   60.58  3.83e-04  5.231e-02    1.438e+10  4.92e+06  91.62 Gflops
    Second location :        1   5.107e-02   19.71  1.01e-05  5.107e-02    4.753e+09  1.72e+05  93.08 Gflops
    Third location  :        1   5.106e-02   19.71  8.14e-06  5.106e-02    4.753e+09  2.75e+05  93.10 Gflops
    ----------------+----------+---------------------------------------+-----------------------------
    Sections per process         2.590e-01                               2.388e+10            92.20 Gflops
    ----------------+----------+---------------------------------------+-----------------------------
    Sections total job           2.590e-01                               9.553e+10           368.79 Gflops
```

Intel Xeon Test1 : HWPC_CHOOSERにFLOPSを指定

詳細レポート(計算量の自動測定):プロセス毎の詳細レポート

```
# PMlib Process Report --- Elapsed time for individual MPI ranks ------

Label  First location
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   flop|msg    speed
Rank     0 :        3  1.569e-01   60.6  3.917e-04  5.228e-02  1.438e+10  9.167e+10 Flops (HWPC)
Rank     1 :        3  1.572e-01   60.7  0.000e+00  5.241e-02  1.438e+10  9.145e+10 Flops (HWPC)
Rank     2 :        3  1.572e-01   60.7  6.914e-05  5.239e-02  1.438e+10  9.148e+10 Flops (HWPC)
Rank     3 :        3  1.564e-01   60.4  8.388e-04  5.214e-02  1.437e+10  9.187e+10 Flops (HWPC)
Label  Second location
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   flop|msg    speed
Rank     0 :        1  5.107e-02   19.7  2.861e-06  5.107e-02  4.753e+09  9.306e+10 Flops (HWPC)
Rank     1 :        1  5.106e-02   19.7  1.383e-05  5.106e-02  4.753e+09  9.309e+10 Flops (HWPC)
Rank     2 :        1  5.106e-02   19.7  2.193e-05  5.106e-02  4.753e+09  9.310e+10 Flops (HWPC)
Rank     3 :        1  5.108e-02   19.7  0.000e+00  5.108e-02  4.753e+09  9.306e+10 Flops (HWPC)
Label  Third location
Header ID  :     call   time[s] time[%]  t_wait[s]  t[s]/call   flop|msg    speed
Rank     0 :        1  5.105e-02   19.7  1.407e-05  5.105e-02  4.753e+09  9.310e+10 Flops (HWPC)
Rank     1 :        1  5.107e-02   19.7  0.000e+00  5.107e-02  4.754e+09  9.309e+10 Flops (HWPC)
Rank     2 :        1  5.105e-02   19.7  1.597e-05  5.105e-02  4.753e+09  9.311e+10 Flops (HWPC)
Rank     3 :        1  5.106e-02   19.7  2.146e-06  5.106e-02  4.753e+09  9.308e+10 Flops (HWPC)
```

Intel Xeon Test1：HWPC_CHOOSERにFLOPSを指定

詳細レポート（計算量の自動測定）：HWPCレポート

```
# PMlib hardware performance counter (HWPC) Report -------------------------
Label   First location
Header  ID :     SP_OPS     DP_OPS    [Flops]
Rank     0 :  1.438e+10  4.400e+01  9.167e+10
Rank     1 :  1.438e+10  2.900e+01  9.145e+10
Rank     2 :  1.438e+10  2.800e+01  9.148e+10
Rank     3 :  1.437e+10  2.800e+01  9.187e+10
Label   Second location
Header  ID :     SP_OPS     DP_OPS    [Flops]
Rank     0 :  4.753e+09  8.000e+00  9.306e+10
Rank     1 :  4.753e+09  1.000e+01  9.309e+10
Rank     2 :  4.753e+09  1.200e+01  9.310e+10
Rank     3 :  4.753e+09  1.100e+01  9.306e+10
Label   Third location
Header  ID :     SP_OPS     DP_OPS    [Flops]
Rank     0 :  4.753e+09  1.100e+01  9.310e+10
Rank     1 :  4.754e+09  1.400e+01  9.309e+10
Rank     2 :  4.753e+09  1.200e+01  9.311e+10
Rank     3 :  4.753e+09  9.000e+00  9.308e+10
```

Intel Xeon : HWPCレポートの記号

printDetail()関数へのlegend引数指定で表示（表示項目はシステム毎に異なる）

```
Detected CPU architecture:
       GenuineIntel
       Intel(R) Xeon(R) CPU E5-2670 0 @ 2.60GHz
       The available PMlib HWPC events for this CPU are shown below.
       The values for each process as the sum of threads.
   HWPC events legend:
       FP_OPS: floating point operations
       SP_OPS: single precision floating point operations
       DP_OPS: double precision floating point operations
       VEC_SP: single precision vector floating point operations
       VEC_DP: double precision vector floating point operations
       LD_INS: memory load instructions
       SR_INS: memory store instructions
       L1_HIT: level 1 cache hit
       L2_HIT: level 2 cache hit
       L3_HIT: level 3 cache hit
       HIT_LFB cache line fill buffer hit
       L1_TCM: level 1 cache miss
       L2_TCM: level 2 cache miss
       L3_TCM: level 3 cache miss by demand
       OFFCORE: demand and prefetch request cache miss
       TOT_CYC: total cycles
       TOT_INS: total instructions
       FP_INS: floating point instructions
   Derived statistics:
       [GFlops]: floating point operations per nano seconds (10^-9)
       [Mem GB/s]: memory bandwidth in load+store GB/s
       [L1$ %]: Level 1 cache hit percentage
       [LL$ %]: Last Level cache hit percentage
```

Intel Xeon Test2 : HWPC_CHOOSERにFLOPSを指定

基本レポート:計算量の自動測定

```
# PMlib Basic Report -----------------------------------------------------

    Timing Statistics Report from PMlib version 4.1.4
    Linked PMlib supports: MPI, OpenMP, HWPC
    Host name : vsp21
    Date      : 2015/10/27 : 19:59:34
    Mr. Bean
    Parallel Mode:   Hybrid (4 processes x 8 threads)
    The environment variable HWPC_CHOOSER=FLOPS is provided.

    Total execution time            = 2.097340e-01 [sec]
    Total time of measured sections = 2.073585e-01 [sec]

    Exclusive Sections statistics per process and total job.

    Section         |    call   |        accumulated time[sec]           | [flop counts or byte counts ]
    Label           |           |      avr   avr[%]      sdv   avr/call  |       avr       sdv   speed
    ----------------+-----------+----------------------------------------+----------------------------
    First location  :         1   1.563e-01  75.36  5.31e-04  1.563e-01   1.436e+10  1.76e+07  91.91 Gflops
    Second location :         1   5.110e-02  24.64  6.58e-05  5.110e-02   4.756e+09  3.41e+05  93.07 Gflops
    ----------------+-----------+----------------------------------------+----------------------------
    Sections per process          2.074e-01                               1.912e+10            92.20 Gflops
    ----------------+-----------+----------------------------------------+----------------------------
    Sections total job            2.074e-01                               7.647e+10           368.78 Gflops
```

Intel Xeon Test1：HWPC_CHOOSERにBANDWIDTHを指定

```
# PMlib Basic Report ------------------------------------------------------
（部分的に表示）

 Section          |    call  |        accumulated time[sec]           | [flop counts or byte counts ]
    Label         |          |      avr   avr[%]      sdv   avr/call  |       avr       sdv    speed
    --------------+----------+-----------------------------------------+-------------------------------
    First location  :       3   1.565e-01  60.50  4.86e-04  5.216e-02    3.683e+10  3.53e+07 235.32 GB/sec
    Second location :       1   5.109e-02  19.75  2.36e-05  5.109e-02    1.229e+10  8.38e+05 240.65 GB/sec
    Third location  :       1   5.109e-02  19.75  4.35e-05  5.109e-02    1.229e+10  4.76e+05 240.63 GB/sec
    --------------+----------+-----------------------------------------+-------------------------------
    Sections per process        2.587e-01                                6.141e+10           237.42 GB/sec
    --------------+----------+-----------------------------------------+-------------------------------
    Sections total job          2.587e-01                                2.457e+11           949.69 GB/sec

# PMlib Process Report --- Elapsed time for individual MPI ranks ------
（部分的に表示）
Label  First location
Header ID  :     call    time[s] time[%]  t_wait[s]  t[s]/call    flop|msg    speed
Rank     0 :        3  1.560e-01   60.3  1.176e-03  5.199e-02  3.686e+10  2.364e+11 Bytes/s (HWPC)
Rank     1 :        3  1.564e-01   60.5  7.520e-04  5.213e-02  3.685e+10  2.356e+11 Bytes/s (HWPC)
Rank     2 :        3  1.571e-01   60.8  0.000e+00  5.238e-02  3.679e+10  2.341e+11 Bytes/s (HWPC)
Rank     3 :        3  1.565e-01   60.5  6.628e-04  5.216e-02  3.681e+10  2.352e+11 Bytes/s (HWPC)

# PMlib hardware performance counter (HWPC) Report ------------------------
（部分的に表示）
Label   First location
Header  ID :     LD_INS     SR_INS     L1_HIT    HIT_LFB L2_DRD_REQ L2_DRD_HIT L2_PF_MISS L2_RFO_MIS   [HW B/s]
Rank     0 :  3.103e+09  9.339e+06  2.540e+09  5.501e+08  3.200e+08  1.844e+08  4.403e+08  3.217e+04  2.364e+11
Rank     1 :  3.103e+09  9.296e+06  2.539e+09  5.503e+08  3.202e+08  1.844e+08  4.399e+08  3.257e+04  2.356e+11
Rank     2 :  3.097e+09  8.414e+06  2.535e+09  5.489e+08  3.204e+08  1.847e+08  4.390e+08  3.122e+04  2.341e+11
Rank     3 :  3.097e+09  8.443e+06  2.534e+09  5.499e+08  3.203e+08  1.845e+08  4.393e+08  3.111e+04  2.352e+11
```

本日はお疲れさまでした