Profiling and Debugging Tools

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Outline

- General (Analysis Tools)
- Listings & Reports
- Timers
- Profilers (gprof, tprof, Tau)
- Hardware performance analysis (PAPI)
- Trace Tools (Paraver, ITC/ITA, KOJAK)
- mpiP
- Debugging (gdb, DDT)

Analysis Tools

- Determine the TIME spent in each "part" (subroutines, functions or even blocks) of your code.
- Within the most time-consuming sections determine if optimization will improve performance.
- General techniques for analyzing code:
  - Compiler reports and listings
  - Profiling
  - Hardware performance counters

Listings & Reports (Compiler/Loader)

- Compilers will optionally generate optimization reports & listing files.
- Use the Loader Map to determine what libraries you have loaded.

Listings & Reports (Compiler/Loader)

- IA32/EM64T:
  - <compiler> -Minfo=time,loop,inline,sym… {(pgi)}
  - <compiler> -opt-report {optimization, (Intel)}
  - <compiler> -S {listing (Intel)}

Timers: Package

The **`time`** command is available on most Unix systems.
It times the execution of a process and its children.

```
/usr/bin/time -p ./a.out
real      1.54
user      0.51
sys        .73
```

Time for a.out execution. Output (in seconds).

e.g. for interactive batch, execution time of mpirun (and a.out):

Bourne shell: `/usr/bin/time -p ibrun  ./a.out args > out 2>&1`

C shell: `/usr/bin/time -p ibrun  ./a.out args >& out`

Types of performance analysis information

- Wall clock/CPU time spent on each function
- HW counters (e.g., cache misses, FLOPs)

Tools:

1. profiler
2. profile visualizer
3. API to read/display HW counter info

- trace file (raw)
- timeline
  - state of thread/process
  - communication
  - predefined user events

Tools:

1. trace generator
2. instrumentation API
3. tool for reading/ interpreting trace files
4. visualizer

Timers: Code Section

Routine	Type	Resolution (usec)	OS/Compiler
times	user/sys	1000	Linux/AIX/IRIX/ UNICOS
getrusage	wall/user/sys	1000	Linux/AIX/IRIX
gettimeofday	wall clock	1	Linux/AIX/IRIX/ UNICOS
rdtsc	wall clock	0.1	Linux
read_real_time	wall clock	0.001	AIX
system_clock	wall clock	system dependent	Fortran 90 Intrinsic
MPI_Wtime	wall clock	system dependent	MPI Library (C & Fortran)

Timers: Code Section

The **times**, **getrussage**, **gettimeofday**, **rdtsc**, and **read_real_time** timers have been packaged into a group of C wrapper routines (also callable from Fortran).

```
external   x_timer
real*8   :: x_timer
real*8   :: sec0, sec1, tseconds
…
sec0     = x_timer()
  …Fortran Code
sec1     = x_timer()
tseconds = sec1-sec0
```

```
double x_timer(void);
             …
double sec0, sec1, tseconds;
…
sec0     = x_timer();
…C Codes
sec1     = x_timer();
tseconds = sec1-sec0
```

X = {one of rusage, gtod, rdtsc, rrt}

http://www.tacc.utexas.edu/services/userguides/porting/#timers

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Profilers: gprof (instrumentation)

<compiler> -g –p prog.<x>

gprof <executable> gmon.out

E.G.

ifort –g –p prog.f90

./a.out

gprof ./a.out gmon.out or gprof

-g provides more info on intrinsics & libs

generates gmon.out

a.out & gmon.out are defaults

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Profilers: Example Code

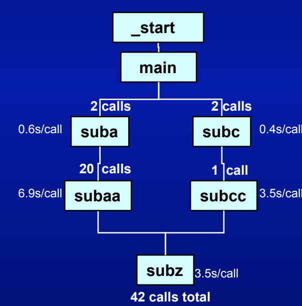
- Program Structure

Code Outline

```
program prof1
   ...
   do i = 1,2
      call suba(n,a,b,c)
   enddo
   do i = 1,2
      call subc(n,a,b,c)
   enddo
end

subroutine suba(n,a,b,c)
   ...
   call subaa(n,a,b,c)
end

subroutine subc(n,a,b,c)
   ...
   call subcc(n,a,b,c)
end
```

```
subroutine subaa(n,a,b,c)
   ...
   do i = 1,20
      ...
      call subz(n,a,b,c)
   end do
end

subroutine subcc(n,a,b,c)
   ...
   call subz(n,a,b,c)
end

subroutine subz(n,a,b,c)
...
end
```

Call Graph



Profiler Example: gprof (output)

- A common Unix profiling tool is **gprof**. Compiler options and libraries provide wrappers for each routine call (mcount), and periodic sampling the program counter (0.01 sec).

% time	cumulative secs	self secs	calls	self ms/call	total ms/call	name
86.21	145.6	145.6	42	3468	3468	subz_
8.18	159.4	13.8	2	6910	76262	subaa_
4.10	166.4	6.9	2	3465	6933	subcc_
0.72	167.6	1.2	2	610	76872	suba_
0.52	168.5	0.88	2	440	7372	subc_
0.26	168.9	0.44	2	440	168930	main
0.01	168.9	0.01	1			write

Profiler Example: gprof (call graph)

```
granularity: each sample hit covers 4 byte(s)
             for 0.01% of 168.94 seconds
index % time    self  children    called   name
                0.44  168.49       1/1         _start [2]
[1]    100      0.44  168.49       1       main        [1]
                1.22  152.52       2/2         suba_  [3]
                0.88   13.87       2/2         subc_  [6]
-----------------------------------------------------
                1.22  152.52       2/2         main    [1]
[3]      91     1.22  152.52       2       suba_       [3]
               13.82  138.70       2/2         subaa_ [4]
-----------------------------------------------------
               13.82  138.70       2/2         suba_  [3]
[4]      90    13.82  138.70       2       subaa_      [4]
              138.70    0.00      40/42        subz_  [5]
-----------------------------------------------------
```

Profiler Example: gprof (output cont.)

```
 6.94    0.00      2/42       subcc_ [7]
              138.70    0.00      40/42        subaa_ [4]
[5]      86   145.64    0.00      42       subz_       [5]
-----------------------------------------------------
                0.88   13.87      2/2          main    [1]
[6]       8     0.88   13.87      2        subc_       [6]
                6.93    6.94      2/2          subcc_ [7]
-----------------------------------------------------
                6.93    6.94      2/2          subc_  [6]
[7]       8     6.93    6.94      2        subcc_      [7]
                6.94    0.00      2/42         subz_  [5]
-----------------------------------------------------
```

Profiling Parallel Programs (gprof)

mpif90 -gp prog.f90	Instruments code
setenv GMON_OUT_PREFIX gout.*	Forces each task to produce a gout.<pid>
Submit parallel job for executable **(in this case named a.out)**	Produces gmon.out trace file
gprof -s gout.*	Combines gout.<pid> files into gmon.sum file
gprof a.out gmon.sum	Reads executable (a.out) & gmon.sum, report sent to STDOUT

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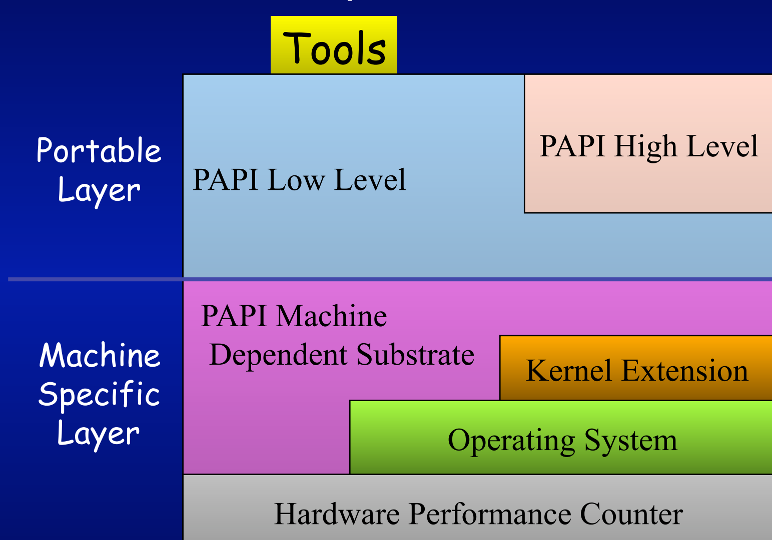
PAPI Implementation



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PAPI Performance Monitor

- Provides high level counters for events:
  - Floating point instructions/operations,
  - Total instructions and cycles
  - Cache accesses and misses
  - Translation Lookaside Buffer (TLB) counts
  - Branch instructions taken, predicted, mispredicted
- PAPI_flops routine for basic performance analysis
  - Wall and processor times
  - Total floating point operations and MFLOPS

  http://icl.cs.utk.edu/projects/papi
- Low level functions are thread-safe, high level are not

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PAPI Preset Events

- Proposed standard set of events deemed most relevant for application performance tuning
- Defined in papiStdEventDefs.h
- Mapped to native events on a given platform
  - Run tests/avail to see list of PAPI preset events available on a platform

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High-level Interface

- Meant for application programmers wanting coarse-grained measurements
- Not thread safe
- Calls the lower level API
- Allows only PAPI preset events
- Easier to use and less setup (additional code) than low-level

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High-level API

- C interface
  PAPI_start_counters
  PAPI_read_counters
  PAPI_stop_counters
  PAPI_accum_counters
  PAPI_num_counters
  PAPI_flips
  PAPI_ipc

- Fortran interface
  PAPIF_start_counters
  PAPIF_read_counters
  PAPIF_stop_counters
  PAPIF_accum_counters
  PAPIF_num_counters
  PAPIF_flips
  PAPIF_ipc

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Low-level Interface

- Increased efficiency and functionality over the high level PAPI interface
- About 40 functions
- Obtain information about the executable and the hardware
- Thread-safe
- Fully programmable
- Callbacks on counter overflow

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TAU Performance Toolkit

- Tuning and Analysis Utilities (11+ year project effort)
  - http://www.cs.uoregon.edu/research/paracomp/tau/
- *Performance system framework* for scalable parallel and distributed high-performance computing
- Targets a general complex system computation model
  - Nodes / Contexts / Threads
  - Multi-level: system / software / parallelism
  - Measurement and analysis abstraction
- *Integrated toolkit* for performance instrumentation, measurement, analysis, and visualization
  - Portable performance profiling and tracing facility
  - Open software approach with technology integration

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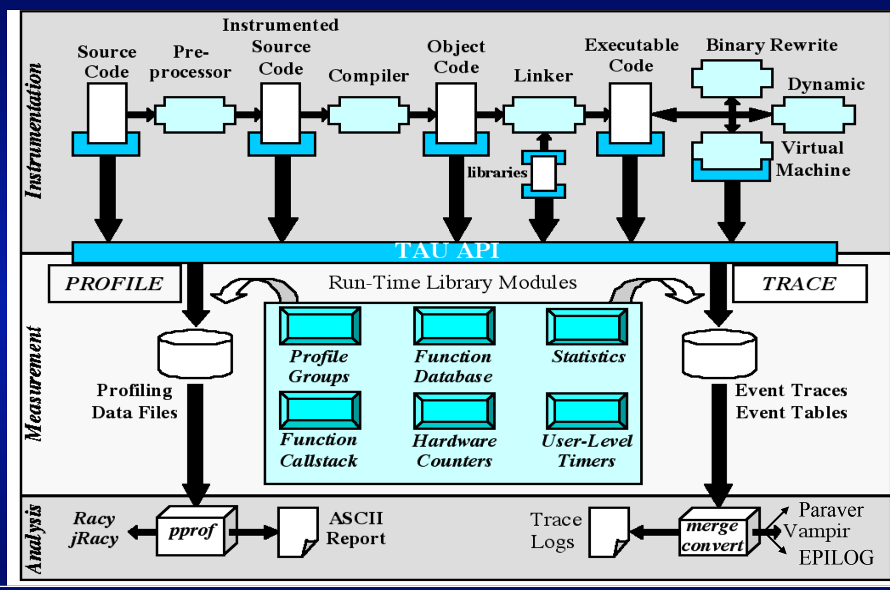
TAU Performance System Architecture



TAU Measurement Options

- Parallel profiling
  - Function-level, block-level, statement-level
  - Supports user-defined events
  - TAU parallel profile data stored during execution
  - Hardware counts values
  - Support for multiple counters
  - Support for callgraph and callpath profiling
- Tracing
  - All profile-level events
  - Inter-process communication events
  - Trace merging and format conversion

TAU Instrumentation

- Manually using TAU instrumentation API
- Automatically using
  - Program Database Toolkit (PDT)
  - MPI profiling library
  - Opari OpenMP rewriting tool
- Uses PAPI to access hardware counter data

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Program Database Toolkit (PDT)

- Program code analysis framework for developing source-based tools
- High-level interface to source code information
- Integrated toolkit for source code parsing, database creation, and database query
  - commercial grade front end parsers
  - portable IL analyzer, database format, and access API
  - open software approach for tool development
- Target and integrate multiple source languages
- Used by TAU to build automated performance instrumentation tools

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TAU Analysis

- Parallel profile analysis
  - *Pprof*
    - parallel profiler with text-based display
  - *ParaProf*
    - Graphical, scalable, parallel profile analysis and display
- Trace analysis and visualization
  - Trace merging and clock adjustment (if necessary)
  - Trace format conversion (SDDF, VTF, Paraver)
  - Trace visualization using Intel Trace Analyzer (Pallas VAMPIR)

TAU Instrumentation

PDT is used to instrument your code.

Replace mpicc and mpif90 in make files with tau_f90.sh and tau_cc.sh

But it is necessary to specify all the components that will be used in the instrumentation (mpi, openmp, profiling, counters [PAPI], etc. But these come in a limited combination.

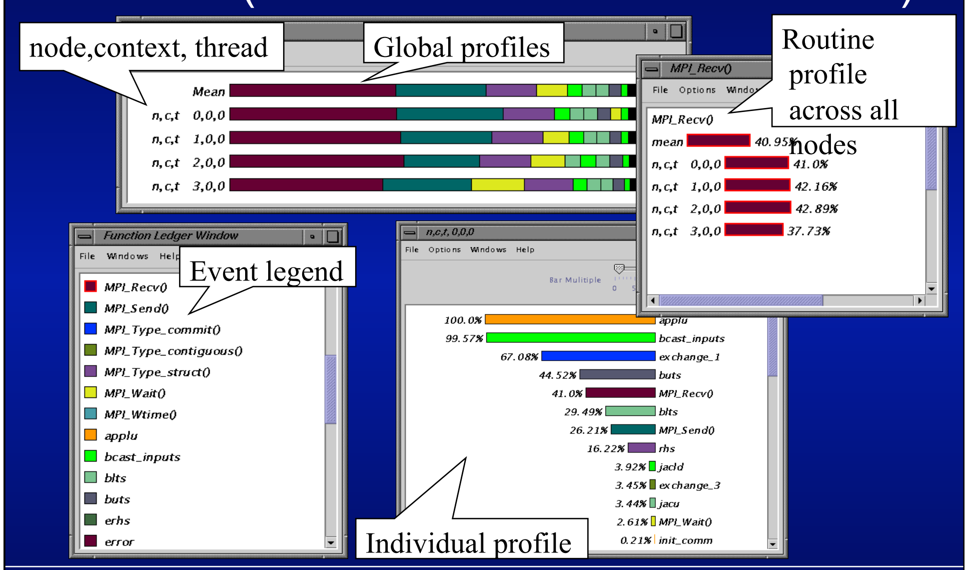
Combinations: First determine what you want to do (profiling, PAPI counters, tracing, etc.) and the programming paradigm (mpi, openmp), and the compiler. PDT is a require component:

Instrumentation	Parallel Paradigm	Collectors	Compiler:
PDT hand-code	MPI OMP …	PAPI Callpath …	intel pgi gnu

TAU: Instrumentation

- You can view the available combinations are made known to the compiler wrapper through the TAU_MAKEFILE environment variable. For instance, the PDT instrumention (pdt) for the Intel compiler (icpc) for MPI (mpi) is set with this command:
  - `setenv TAU_MAKEFILE   /…/Makefile.tau-icpc-mpi-pdt`
- Other run-time and instrumentation options are set through TAU_OPTIONS. For verbose:
  - `setenv TAU_OPTIONS   '-optVerbose'`
-

ParaProf (NAS Parallel Benchmark – LU)



TAU Pprof Display

emacs@neutron.cs.uoregon.edu

Buffers Files Tools Edit Search Mule Help

Reading Profile files in profile.*

NODE 0;CONTEXT 0;THREAD 0:

%Time	Exclusive msec	Inclusive total msec	#Call	#Subrs	Inclusive usec/call	Name
100.0	1	3:11.293	1	15	191293269	applu
99.6	3,667	3:10.463	3	37517	63487925	bcast_inputs
67.1	491	2:08.326	37200	37200	3450	exchange_1
44.5	6,461	1:25.159	9300	18600	9157	buts
41.0	1:18.436	1:18.436	18600	0	4217	MPI_Recv()
29.5	6,778	56,407	9300	18600	6065	blts
26.2	50,142	50,142	19204	0	2611	MPI_Send()
16.2	24,451	31,031	301	602	103096	rhs
3.9	7,501	7,501	9300	0	807	jacld
3.4	838	6,594	604	1812	10918	exchange_3
3.4	6,590	6,590	9300	0	709	jacu
2.6	4,989	4,989	608	0	8206	MPI_Wait()
0.2	0.44	400	1	4	400081	init_comm
0.2	398	399	1	39	399634	MPI_Init()
0.1	140	247	1	47616	247086	setiv
0.1	131	131	57252	0	2	exact
0.1	89	103	1	2	103168	erhs
0.1	0.966	96	1	2	96458	read_input
0.0	95	95	9	0	10603	MPI_Bcast()
0.0	26	44	1	7937	44878	error
0.0	24	24	608	0	40	MPI_Irecv()
0.0	15	15	1	5	15630	MPI_Finalize()
0.0	4	12	1	1700	12335	setbv
0.0	7	8	3	3	2893	l2norm
0.0	3	3	8	0	491	MPI_Allreduce()
0.0	1	3	1	6	3874	pintgr
0.0	1	1	1	0	1007	MPI_Barrier()
0.0	0.116	0.837	1	4	837	exchange_4
0.0	0.512	0.512	1	0	512	MPI_Keyval_create()
0.0	0.121	0.353	1	2	353	exchange_5
0.0	0.024	0.191	1	2	191	exchange_6
0.0	0.103	0.103	6	0	17	MPI_Type_contiguous()

--:-- NPB_LU.out (Fundamental)--L8--Top----

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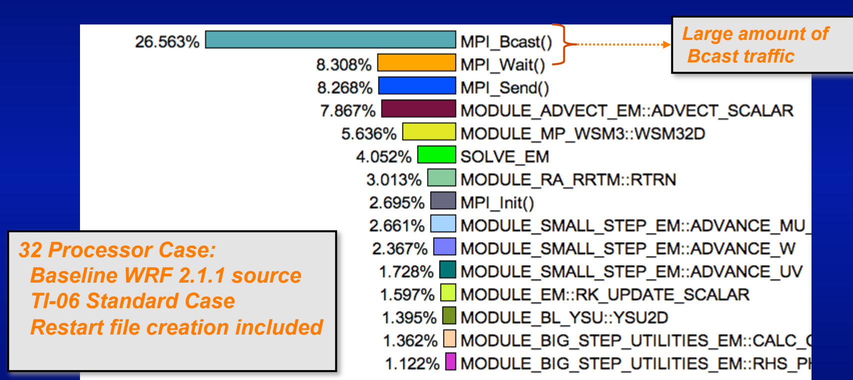
TAU Usage for Optimization/Debugging



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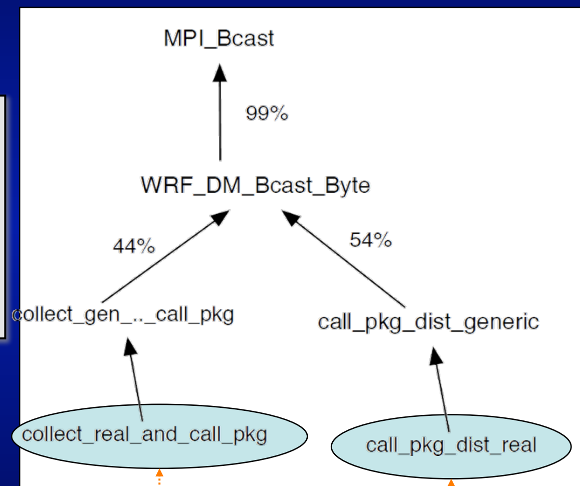
Initial TAU Profiling With I/O Included

TAU used to generate callpath. These routines were tracked back to the restart file creation which inflates Bcast calls.

Altered WRF to disable output file creation.

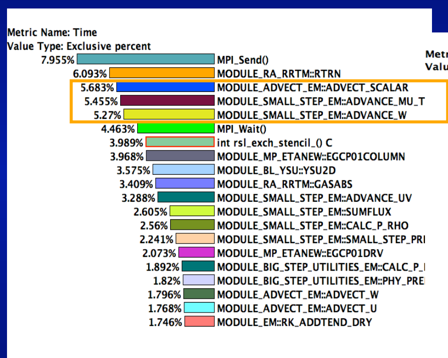


Profiling Analysis

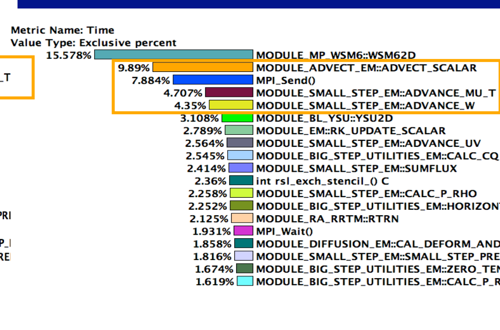
- Typical Performance Analysis Goals
  - Identify hotspot candidates for further study and optimization potential
  - Test optimization changes to verify usefulness
  - Floating-point improvements aimed at reducing overall wall-clock run time (but may potentially reduce scalability)
  - MPI improvements aimed at reducing MPI Idle time and improve scalability

Example TAU Profiling Results

Standard, 32 Procs



Large, 32 Procs



The computational modules in `module_small_step_em` and `module_advect_em` are top contributors in both the standard and large cases (and are independent of microphysics).

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Floating Point Optimizations

- Looking at the source code, several opportunities were identified for *loop fusion* modifications in:
  - MODULE_SMALL_STEP_EM::advance_w, advance_uv, sumflux, advance_mu_t
  - MODULE_ADVECT_EM::advect_v
- Loop fusion optimizations were tested by monitoring L1 data-cache misses with and without code changes
- Code change optimizations increased data reuse in cache and improved data prefetching.

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Floating Point Optimizations

```
DO k=1, k_end
  DO i=i_start, i_end
    t_2ave(i,k,j)=.5*((1.+epssm)*t_2(i,k,j)+(1.-epssm)*t_2ave(i,k,j))
    t_2ave(i,k,j)=(t_2ave(i,k,j)-mu1(i,j)*t_1(i,k,j))
                  /(muts(i,j)*(t0+t_1(i,k,j)))
  ENDDO
ENDDO
DO k=2,k_end+1
  DO i=i_start, i_end
       wdwn(i,k)=.5*(ww(i,k,j)+ww(i,k-1,j))*rdnw(k-1)     &
                   *(ph_1(i,k,j)-ph_1(i,k-1,j)+phb(i,k,j)-phb(i,k-1,j))
       rhs(i,k) = dts*(ph_tend(i,k,j) + .5*g*(1.-epssm)*w(i,k,j))
  ENDDO
ENDDO
```

Original Code

```
DO k=1, k_end
  DO i=i_start, i_end
    t_2ave(i,k,j)=.5*((1.+epssm)*t_2(i,k,j)+(1.-epssm)*t_2ave(i,k,j))
    t_2ave(i,k,j)=(t_2ave(i,k,j)-mu1(i,j)*t_1(i,k,j)) &
                  /(muts(i,j)*(t0+t_1(i,k,j)))
    wdwn(i,k+1)=.5*(ww(i,k+1,j)+ww(i,k,j))*rdnw(k)     &
           *(ph_1(i,k+1,j)-ph_1(i,k,j)+phb(i,k+1,j)-phb(i,k,j))
    rhs(i,k+1) = dts*(ph_tend(i,k+1,j) + .5*g*(1.-epssm)*w(i,k+1,j))
  ENDDO
ENDDO
```

Optimized Code

Example of Code Optimization (in advance_w)

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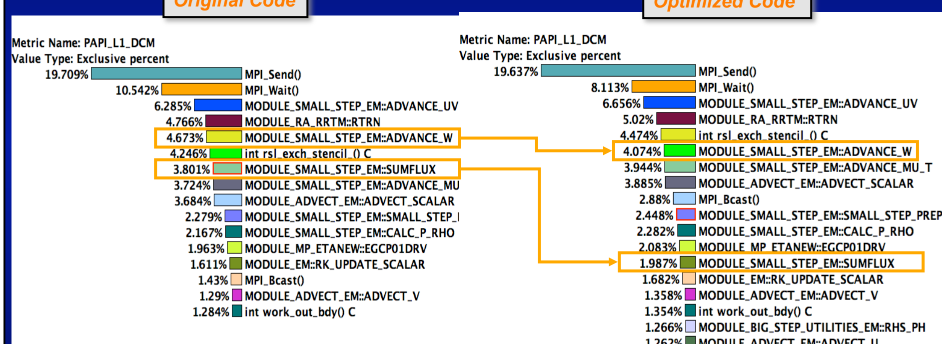
Floating Point Optimizations

32 Processors, L1 Data Cache Misses (DCMs)

Original Code *Optimized Code*



Combined effect of all loop fusion modifications was a reduction of ~2E9 L1 DCMs over the entire run.

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Standard Debuggers

- The standard command line debugging tool is **gdb** in Linux. You can use these debuggers for programs written in C, C++ and Fortran.
- For effective debugging a couple of commands need to be mastered – set breakpoints, display the value of variables, set new values, and single step through a program. Less used commands can be learned as they become necessary.
- A High Level interface allows users to start, stop and record events. (Provides a “standard” set of controls)
- A Low Level interface allows developers to manipulate events and variables.

Debugging Basics

- For effective debugging a couple of commands need to be mastered:
  – show program backtraces (the calling history up to the current point)
  – set breakpoints
  – display the value of individual variables
  – set new values
  – step through a program

Debugging Basics

- A breakpoint is a pseudo instruction that the user can insert at any place into the program during a debugging session
- Conceptually, the execution is controlled by the debugger and the debugger will interpret the breakpoints
- When execution crosses a breakpoint, the debugger will pause program execution so that you can:
  - inspect variables,
  - set or clear breakpoints, and
  - continue execution

Debugging Basics

- The notion of a conditional breakpoint also exists in which additional logic can be associated with the breakpoint
- When a conditional breakpoint is crossed during execution, the program will pause only if the breakpoint's break condition holds
- Example break conditions:
  - A given expression is true
  - The breakpoint has been crossed N times ("hit count") - this is very handy when you know something bad is happening on a particular iteration
  - A given expression has changed its value

Running GDB

- gdb is started directly from the shell
- You can include the name of the program to be debugged, and an optional core file:
  - `gdb` spawns a new instance of ./a.out
  - `gdb a.out`
  - `gdb a.out corefile` examines trapped state in corefile
- gdb can also attach to a program that is already running; you just need to know the PID associated with the desired process
  - `gdb a.out 1134` useful if an application seems to be slow or stuck and you want to see what it is doing currently

gdb Basics

- Common commands for gdb:
  - run - starts the program; if you do not set up any breakpoints the program will run until it terminates or core dumps - program command line arguments can be specified here
  - print - prints a variable located in the current scope
  - next - executes the current command, and moves to the next command in the program
  - step - steps through the next command. Note: if you are at a function call, and you issue next, then the function will execute and return. However, if you issue step, then you will go to the first line of that function
  - break - sets a break point.
  - continue - used to continue till next breakpoint or termination

Note: shorthand notations exist for most of these commands: eg. 'c' = continue

gdb Basics

- More commands for gdb:
  - list - show code listing near the current execution location
  - delete - delete a breakpoint
  - condition - make a breakpoint conditional
  - display - continuously display value
  - undisplay - remove displayed value
  - where - show current function stack trace
  - help - display help text
  - quit - exit gdb

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mpiP: dynamic MPI Profiling

- Scalable Profiling library for MPI applications
- Lightweight
- Collects statistics of MPI functions
  - uses communication only during report generation
  - less overhead & much less data than tracing tools.
- http://mpip.sourceforge.net

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Usage, Instrumentation, Analysis

- How to use
  - No recompiling required
  - Profiling gathered in MPI profiling layer
- Link Static Library before default MPI libraries
  - **-g** -L${TACC_MPIP_LIB} -lmpiP -lbfd -liberty -lintl –lm
  - mpicc and mpif90 cmd line libs are loaded first.
- What to analyze
  - Overview of time spent in MPI communication during the application run
  - Aggregate time for individual MPI call

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Control

- External Control
  - Set MPIP environment variable (threshold,callsite depth)
    - E.g. setenv MPIP '-t 10 –k 2   export MPIP= '-t 10 –k 2'
- Limiting to specific code blocks
  - MPI_Pcontrol(#)

C

```
MPI_Pcontrol(2);
MPI_Pcontrol(1);
    MPI_Abc(…);
MPI_Pcontrol(0);
```

F90

```
call MPI_Pcontrol(2)
call MPI_Pcontrol(1)
    call MPI_Abc(…)
call MPI_Pcontrol(0)
```

Pcontrol Arg	Behavior
0	Disable profiling.
1	Enable Profiling.
2	Reset all callsite data.
3	Generate verbose report.
4	Generate concise report.

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mpiP: output

- MPI-Time: wall-clock time for all MPI calls within application time

```
---------------------------------------------------------------------------
@--- MPI Time (seconds) ---------------------------------------------------
---------------------------------------------------------------------------
Task    AppTime    MPITime     MPI%
   0         10   0.000243     0.00
   1         10         10    99.92
   2         10         10    99.92
   3         10         10    99.92
   *         40         30    74.94
```

- MPI callsites within application

```
---------------------------------------------------------------------------
@--- Callsites: 2 ---------------------------------------------------------
---------------------------------------------------------------------------
 ID Lev File/Address        Line Parent_Funct             MPI_Call
  1   0 9-test-mpip-time.c    52 main                     Barrier
  2   0 9-test-mpip-time.c    61 main                     Barrier
```

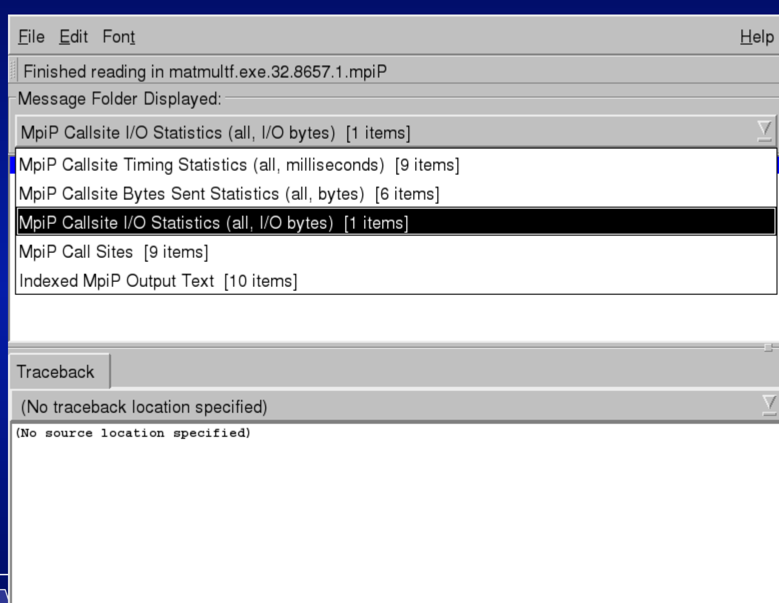
- Aggregation time (top 20 MPI callsites)

```
---------------------------------------------------------------------------
@--- Aggregate Time (top twenty, descending, milliseconds) ----------------
---------------------------------------------------------------------------
Call                 Site       Time    App%    MPI%     COV
Barrier                 2      3e+04   75.00  100.00    0.67
Barrier                 1      0.405    0.00    0.00    0.59
```

- Message size of top 20 callsites

```
---------------------------------------------------------------------------
@--- Aggregate Sent Message Size (top twenty, descending, bytes) ----------
---------------------------------------------------------------------------
Call                 Site      Count      Total    Avrg     MPI%
Send                    7        320   1.92e+06   6e+03    99.96
Bcast                   1         12        336      28     0.02
```

Better view with mpipview



mpipview - output

File Edit Font Help

Finished reading in matmultf.exe.32.8657.1.mpiP

Message Folder Displayed:

Indexed MpiP Output Text [10 items]

```
  2: Invocation Command
  3: mpiP Version
  8: MPIP Environment Variable Setting
 13: MPI Task Assignment
 47: MPI Time Breakdown By MPI Task
 84: Callsites Measured By mpiP
 97: Aggregate Time Statistics for Top Twenty Callsites
110: Aggregate Bytes Sent Statistics for Top Twenty Callsites
120: Detailed Time Statistics for All Callsites
271: Detailed Bytes Sent Statistics for All Callsites
```

Traceback

/work/00770/milfeld/d.mpip/mvapich1_intel/test_matmult/matmultf.exe.32.8657.1.mpiP:47

```
46: ---------------------------------------------------------------------------
47: @--- MPI Time (seconds) ---------------------------------------------------
48: ---------------------------------------------------------------------------
49: Task    AppTime    MPITime     MPI%
50:    0      0.316      0.229    72.45
51:    1      0.315     0.0707    22.45
52:    2      0.315      0.072    22.84
53:    3      0.315     0.0706    22.41
54:    4      0.315     0.0698    22.16
55:    5      0.316     0.0691    21.88
56:    6      0.316       0.07    22.17
57:    7      0.315     0.0691    21.95
58:    8      0.315     0.0681    21.63
```

Call “Sites”

File Edit Font Help

Finished reading in matmultf.exe.32.8657.1.mpiP

Message Folder Displayed:

MpiP Call Sites [9 items]

```
1 main:131 (matmultf.f90)  Barrier
2 main:87  (matmultf.f90)  Recv
3 main:72  (matmultf.f90)  Bcast
4 main:103 (matmultf.f90)  Send
5 main:99  (matmultf.f90)  Send
6 main:81  (matmultf.f90)  Send
7 main:125 (matmultf.f90)  Send
8 main:118 (matmultf.f90)  Recv
9 main:113 (matmultf.f90)  Bcast
```

Barrier[1] Source

matmultf.f90:131 (main)

```
124:             call multiply_matrices(answer, buffer, b, matsize)
125:             call MPI_SEND(answer, matsize, MPI_DOUBLE_PRECISION, master,&
126:                row, MPI_COMM_WORLD, ierr)
127:           endif
128:         end do
129:       endif
130:
131:       call MPI_Barrier (MPI_COMM_WORLD,ierr);
132:       call MPI_FINALIZE(ierr)
133:       end program main
```

Statistics

File Edit Font Help

Finished reading in matmultf.exe.32.8657.1.mpiP

Message Folder Displayed:

MpiP Callsite Timing Statistics (all, milliseconds) [9 items]

Bcast[9]	67.71% of MPI	16.70% of App	31/32 Tasks	main:113	(matmultf.f90)
Recv[8]	18.66% of MPI	4.60% of App	31/32 Tasks	main:118	(matmultf.f90)
Recv[2]	7.11% of MPI	1.75% of App	1/32 Tasks	main:87	(matmultf.f90)
Barrier[1]	3.46% of MPI	0.85% of App	32/32 Tasks	main:131	(matmultf.f90)
Bcast[3]	1.66% of MPI	0.41% of App	1/32 Tasks	main:72	(matmultf.f90)
Send[7]	0.98% of MPI	0.24% of App	31/32 Tasks	main:125	(matmultf.f90)
Send[5]	0.40% of MPI	0.10% of App	1/32 Tasks	main:99	(matmultf.f90)

Recv[8] Source | Raw MpiP Data

matmultf.f90:118 (main)

```
115:         end do
116:         flag = 1
117:         do while (flag .ne. 0)
118:            call MPI_RECV(buffer, matsize, MPI_DOUBLE_PRECISION, master,  &
119:              MPI_ANY_TAG, MPI_COMM_WORLD, status, ierr)
120:            row = status(MPI_TAG)
121:            flag = row
```

TACC

Message Size

File Edit Font Help

Finished reading in matmultf.exe.32.8657.1.mpiP

Message Folder Displayed:

MpiP Callsite Bytes Sent Statistics (all, bytes) [6 items]

Bcast[9]	67.71% of MPI	2.48e+08 Total	8000 Mean	31/32 Tasks	main
Bcast[3]	1.66% of MPI	8000000 Total	8000 Mean	1/32 Tasks	main
Send[7]	0.98% of MPI	8000000 Total	8000 Mean	31/32 Tasks	main
Send[5]	0.40% of MPI	7752000 Total	8000 Mean	1/32 Tasks	main
Send[6]	0.02% of MPI	248000 Total	8000 Mean	1/32 Tasks	main
Send[4]	0.00% of MPI	248 Total	8 Mean	1/32 Tasks	main

Bcast[9] Source | Raw MpiP Data

matmultf.f90:113 (main)

```
110:       else
111: ! workers receive B, then compute rows of C until done message
112:         do i = 1,matsize
113:           call MPI_BCAST(b(1,i), matsize, MPI_DOUBLE_PRECISION, master, &
114:                 MPI_COMM_WORLD, ierr)
115:         end do
116:         flag = 1
```

TACC

Debugging: DDT

Interactive, parallel, symbolic debuggers with GUI interface

- Works with C, C++ and Fortran Compilers
- Available on my different platforms.
  (IBM, CRAY, AMD, INTEL, SUN, SGI, …)
- Supports OpenMP & MPI
  (and hybrid paradigm)
- Support 32- and 64-bit architectures
- Simple to use (intuitive)

Instrumenting Code and Running TotalView

```
% module load ddt    {sets environment variables}
% module help ddt    {foolow instructions}
% ifort -g prog.f90
% ddt &
```