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Center for High-Performance Computing

Debugging with Totalview

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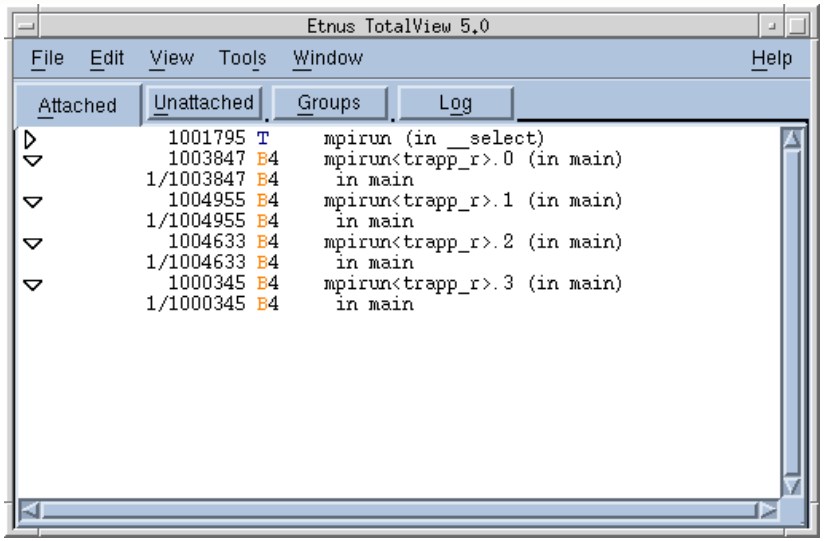
Overview

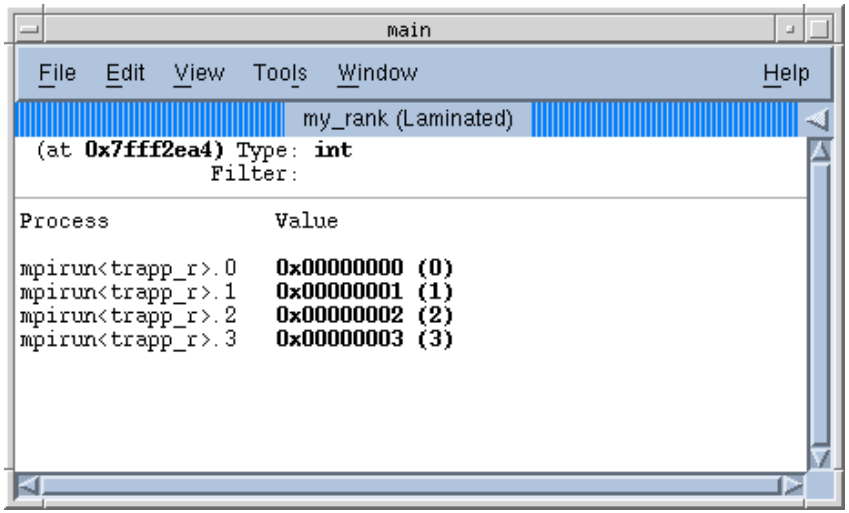
- Totalview introduction.
- Basic operation.
- Serial debugging.
- Parallel debugging.
  - OpenMP
  - MPI
- Memory debugging.
- Some other useful information

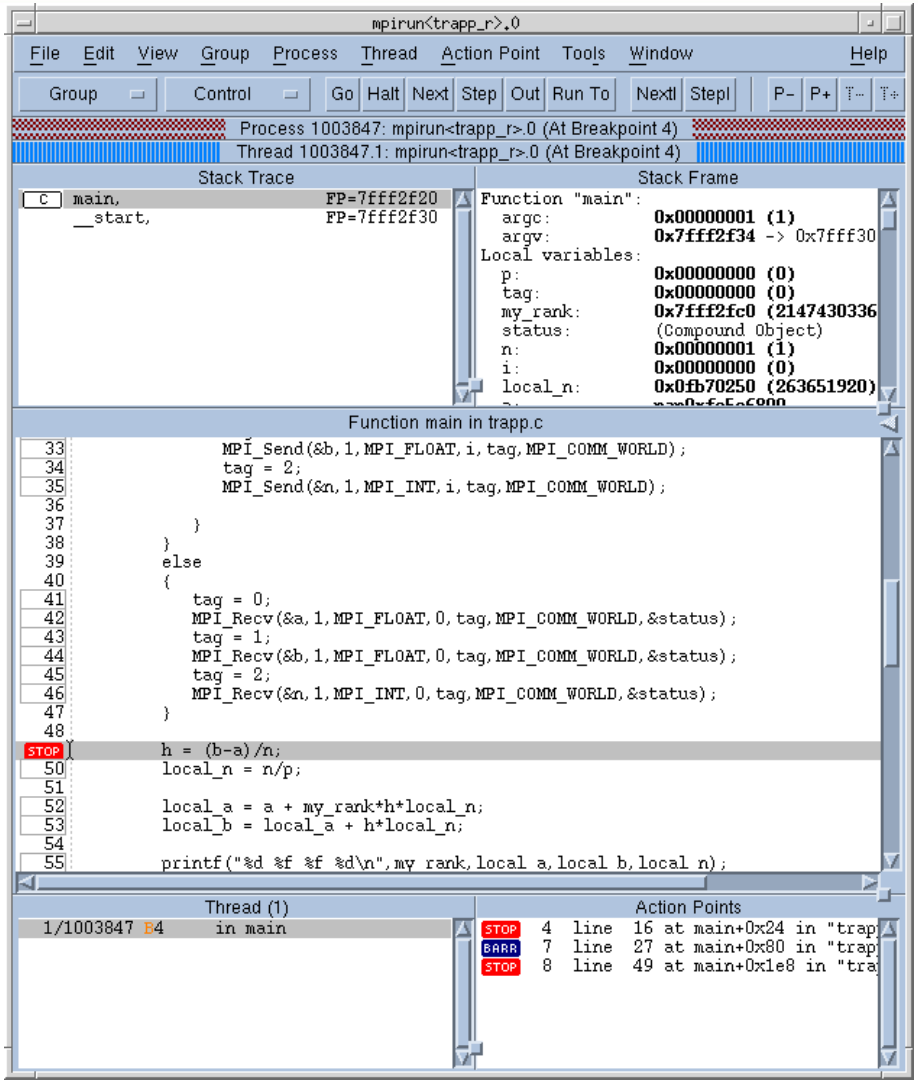
Totalview in a nutshell

- source and machine level debugger
- command line and graphic interface
- serial and parallel debugging support
- supports remote debugging
- runs on variety of platforms

Totalview windows







Totalview basic operations

- Data examination
  - view data in the variable windows
  - change the values of variables
  - modify display of the variables
  - visualize data
- Action points
  - breakpoints and barriers (static or conditional)
  - watchpoints
  - evaluation of expressions

Multiprocess debugging

- Automatic attachment of child processes
- Create process groups
- Share breakpoints among processes
- Process barrier breakpoints
- Process group single-stepping
- “Laminate” variables
- Display MPI message queue state

How to use Totalview

1. Compile binary with debugging information

- flag -g

```
g77 –g test.f –o test
```

- if use fork() or execve(), link …

```
g77 –g –L/…/totalview/linux-x86-64/lib –ldbfork
test.f –o test
```

2. Run Totalview

- TV + executable

```
totalview executable
```

- TV + core file

```
totalview executable core_file
```

How to use Totalview

- run TV and attach the executable
  - start TV
  - menu New Program Window
  - fill in executable file name
- run TV and attach running program
  - start TV
  - menu New Program Window
  - pullout Attach to an Existing Process
  - choose process ID and fill in executable file name

3. Totalview operation

- left mouse button - select
- right mouse button - menu
- left mouse button double click - dive

Example 1 – Serial code

- CUSP – DFT plane wave atomic simulation
  - atomic nuclei interact classically
  - electrons described by wavefunctions - plane waves
  - interaction between w.f.'s and nuclei define the system potential and kinetic energy
  - iterate electronic and nuclear energy to self consistency to achieve ground state
- Implementation
  - 10+ Fortran source code files
  - simple Makefile w/ flags **-g -byteswapio**

Process view window

- Stack trace – procedure hierarchy
- Stack frame – variables display
- Source code – code + process navigation
- Threads list – in case of multithreaded application
- Action points – list of breakpoints, barriers,…

Running the debugger

- Menu Go/Halt/Next/Step/Hold or shortcuts
- Possible actions (thread,process/group):
  - go (g/G)
  - halt (h/H)
  - step (source line) (s/S)
  - step (instruction) (i/I)
  - next (source line) (n/N)
  - next (instruction) (x/X)
  - run (to selection) (r/R)
  - return (out of function) (o/O)

Action points

- Breakpoints and barriers
  - toggle location with left mouse (shift for barrier)
  - right-click – Properties for options
- Evaluation points
  - set conditional breakpoints
  - conditionally patch out code
- Watchpoints
  - watch for change in a memory location

Data examination

- Variable view
  - dive (right mouse) on any variable
  - change data type
  - select an array slice, e.g. (3:3,:)
  - filter array values, e.g. .ne. 0
- Variable visualization
- menu Visualize – only up to 2D arrays

Example 2 – OpenMP code

- Compilation
  - Arches:

```
pathf90 –openmp test.f -g –o test.exe
pgf90 –mp test.f -g –o test.exe
ifort –openmp test.f -g –o test.exe
gcc4 –fopenmp test.c -g –o test.exe
```

- Running
  - set OMP_NUM_THREADS
- Example – saxpy routine
  - simple vector-scalar product

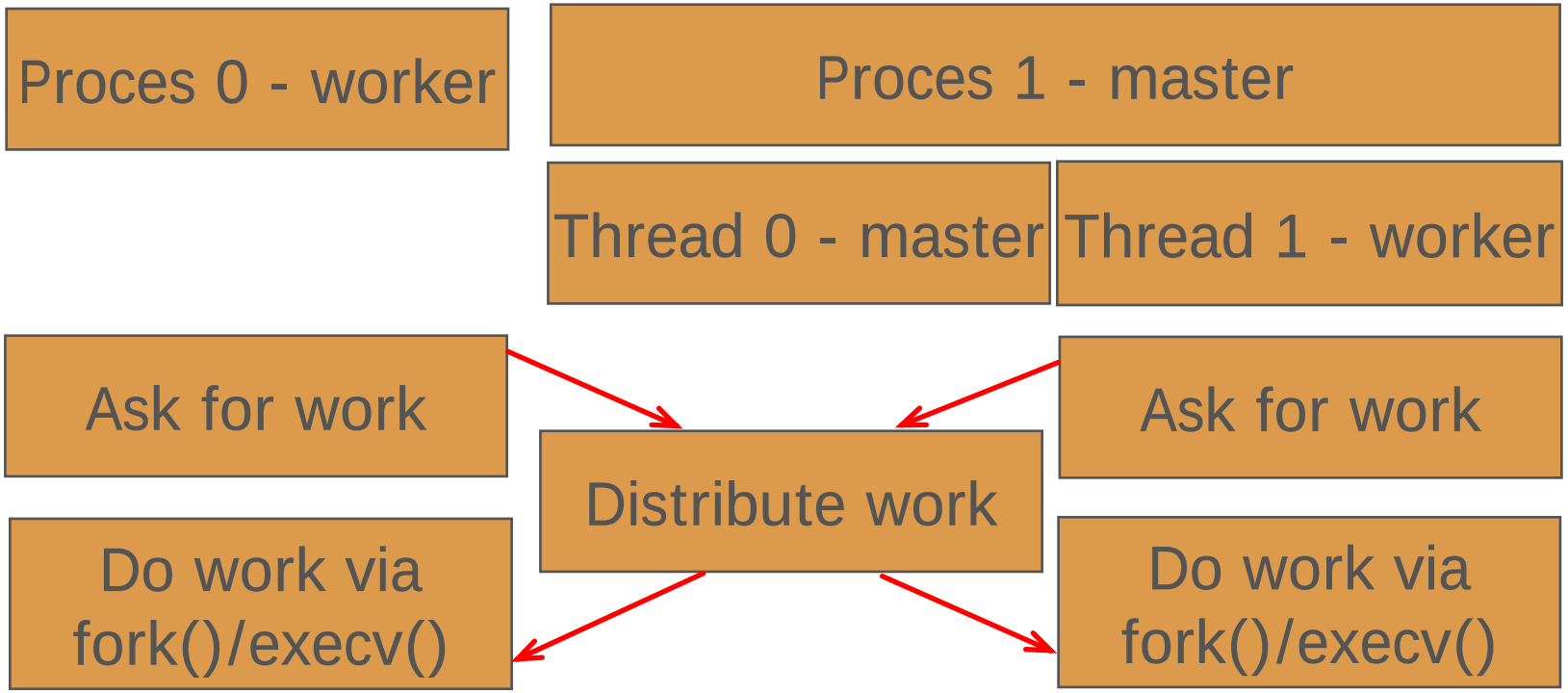
OpenMP specific debugging

- TV automatically attaches all threads
- put breakpoint to OpenMP parallel section to debug threads
- variable lamination - show values from all threads in one window – does not always work
- barrier points – shift-left click
- ambiguous action points – select all

Example 3 – MPI/OpenMP code

- Job submitter code
  - one MPI process – master – distributes work
  - other MPI processes – slaves – do the work
- Implementation
  - master reads job database and sends work information to slaves
  - master runs two threads via OpenMP, one distributes the work, the other runs the work
  - slave processes the information and runs the work (serially via fork() and execve() functions)

Example 3 scheme



Master reads database with available jobs, and sends work requests to available workers

Example 3 – MPI code – Arches

- MPICH2 on interactive nodes
  - good enough for most parallel problems
  - **`source /uufs/arches/sys/pkg/mpich2/std_pgi/etc/mpich2.csh`**
  - **`mpicc submit.o –g -o submit`**

- Running
  - Start MPD daemon on the interactive node
    `mpdboot –n 1`
    if have problems, create ~/.mpd.conf file
  - Run:
    open Totalview (**`totalview`**), then in New Program Window enter:
    - program name
    - MPICH2 for parallel sysem
    - number of processors

Example 3 – MPI code – Arches

- Running on compute nodes
  - use larger number of processors or other MPI than MPICH2 is needed
  - **`pgcc -g -mp -I/uufs/arches/sys/pkg/mpich/std/include submit.c`**
  - **`pgcc submit.o -L/uufs/arches/sys/pkg/mpich/std/lib –lmpich -o submit`**

- Running on compute nodes (large # of processors)
  - contact CHPC to get ssh access to the nodes
  - interactive PBS:
    `qsub -I –l nodes=2,walltime=2:00:00`
    `hostname -i`
  - ssh to node name obtained above

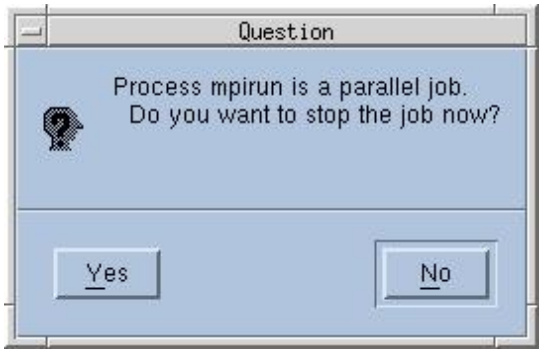
Example 3 – MPI code – Arches

- Running on interactive nodes
- run:

  `/uufs/arches/sys/pkg/mpich/std/bin/mpirun -tv -np 2 -machinefile $PBS_NODEFILE ./submit`
- modify path for the tdsvr – Totalview server:

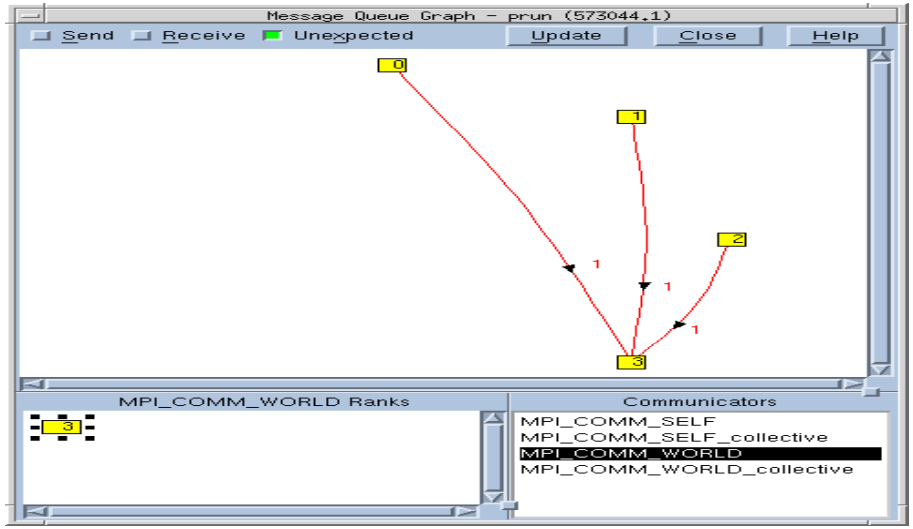
  Menu File – Properties – Launch strings

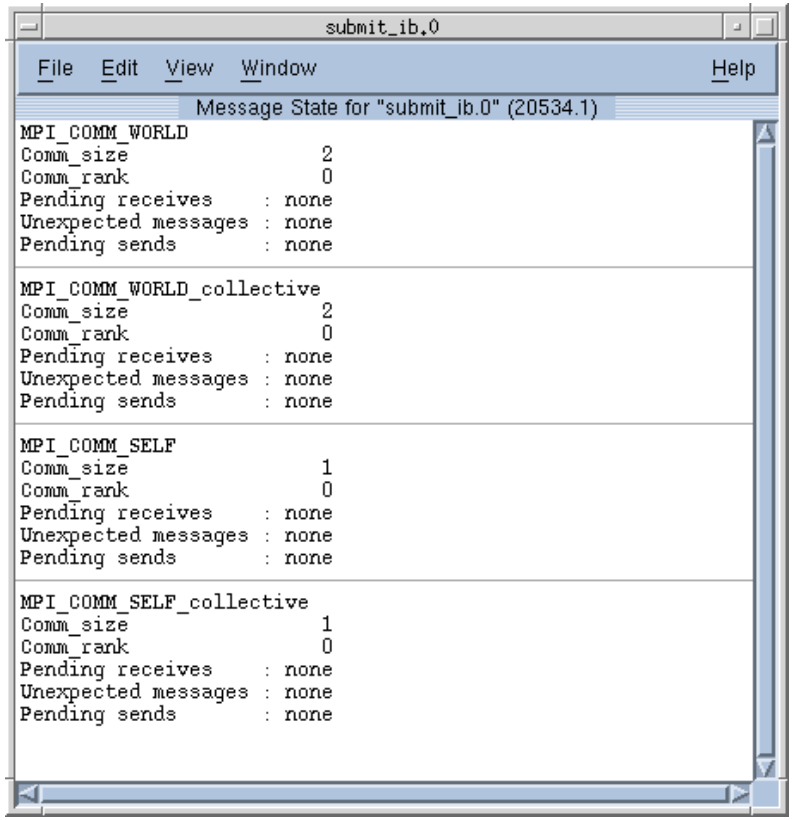
  `/uufs/arches/sys/pkg/totalview/std/bin/tdvsvr`
- Set a breakpoint after MPI_Init and select Go
- Select No or Yes at the next dialog, does not matter since we already have a breakpoint set
- Debug and enjoy



MPI specific debugging

- Process synchronization – program groups
- Barrier points
- Message queue state graph and display





Memory debugging

- display memory status
- paint allocated and deallocated blocks
- find memory leaks
- identify dangling pointers
- enable with **`Tools > Memory Debugger > Enable memory debugging`** checkbox

Some useful resources

- TotalviewTech webpage

  `http://www.totalviewtech.com`

- Location of Totalview

  Arches:**`/uufs/arches/sys/pkg/totalview/std`**

  Some group desktops: **`inquire at CHPC`**

- Documentation

`http://www.totalviewtech.com/Support/docs/index.html`
`http://www.chpc.utah.edu/software/docs/par_devel.html`
`http://www.chpc.utah.edu/software/docs/totalview.html`
`http://www.chpc.utah.edu/short_courses/Totalview`

Totalview Student Edition

- Free for students
- Limited to one computer, 4 processes
- To sign up, e-mail mcuma@chpc.utah.edu:
  - name
  - e-mail
  - university ID
  - anticipated year of graduation
- More details

http://www.totalviewtech.com/academia/totalview_express.html

Code checkers

- compilers check for syntax errors
  - some compiler flags help too (-C)
- memory checking tools - many errors are due to bad memory management
  - valgrind – easy to use
  - purify – harder to use

Thread checking

- Good for finding OpenMP errors
  - race conditions
  - privatization
- Intel thread checker (ITC)
  - OpenMP
  - pthreads

Using ITC

- Source ITC environment

```
source
/uufs/arches/sys/pkg/itc/std/tcheck/bin/32e/tcheckvars
.csh
```

- Compile with `–tcheck -g`

```
ifort -openmp -tcheck -g trap.f
```

- Run tcheck

```
tcheck_cl ./a.out
```

- More info

http://www.intel.com/support/performancetools/threadchecker/linux/

Future Presentations

- Mathematical libraries at the CHPC
- Chemistry packages (Anita Orendt)
- Using Gaussian (Anita Orendt)
- Performance analysis with TAU/Vampir
- Introduction to OpenMP
- MPI-IO
- Mixed MPI/OpenMP programming
  Intermediate MPI ???