Profiling MPI code to identify bottlenecks

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Slides: git.io/fAV4t

MPI, briefly

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- Point-to-all (broadcast) operations
- Collectives, e.g. reductions (sums, maxima, minima, etc.)

Profiling MPI

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source /apps/compilers/intel/2018.3/itac_2018/bin/itacvars.sh
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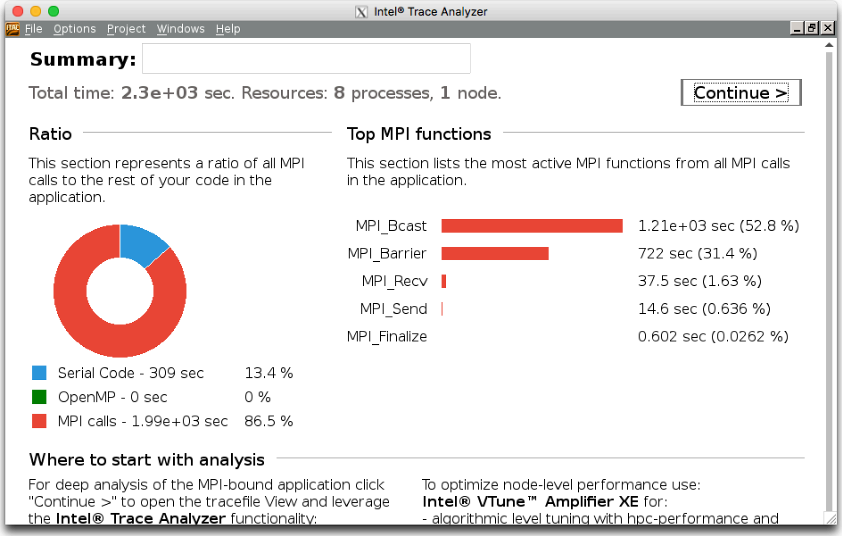
- Visualise the results with `traceanalyzer`

Summary view



Summary:

Total time: **2.3e+03** sec. Resources: **8** processes, **1** node.

Ratio

This section represents a ratio of all MPI calls to the rest of your code in the application.

🟦	Serial Code - 309 sec	13.4 %
🟩	OpenMP - 0 sec	0 %
🟥	MPI calls - 1.99e+03 sec	86.5 %

Top MPI functions

This section lists the most active MPI functions from all MPI calls in the application.

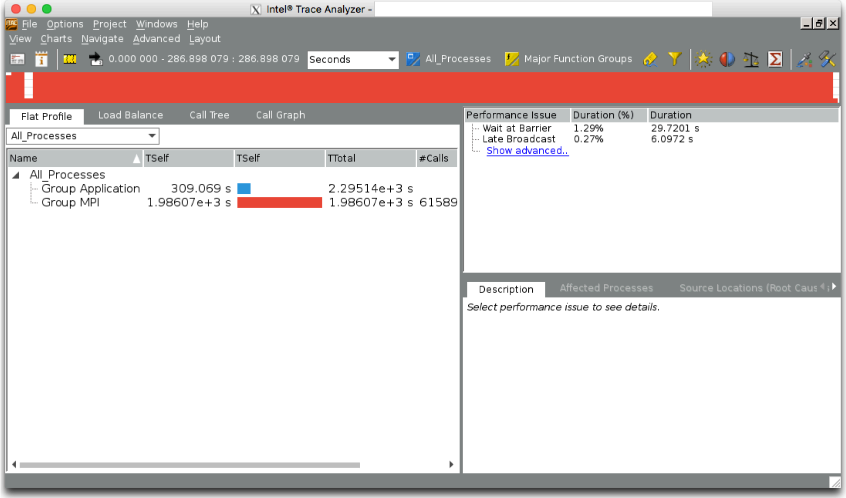
MPI_Bcast	1.21e+03 sec (52.8 %)
MPI_Barrier	722 sec (31.4 %)
MPI_Recv	37.5 sec (1.63 %)
MPI_Send	14.6 sec (0.636 %)
MPI_Finalize	0.602 sec (0.0262 %)

Where to start with analysis

For deep analysis of the MPI-bound application click "Continue >" to open the tracefile View and leverage the **Intel® Trace Analyzer** functionality:

To optimize node-level performance use:
Intel® VTune™ Amplifier XE for:
- algorithmic level tuning with hpc-performance and

Whole application timeline



Name	TSelf	TSelf	TTotal	#Calls
All_Processes				
Group Application	309.069 s	🟦	2.29514e+3 s	
Group MPI	1.98607e+3 s	🟥	1.98607e+3 s	61589

Performance Issue	Duration (%)	Duration
Wait at Barrier	1.29%	29.7201 s
Late Broadcast	0.27%	6.0972 s
Show advanced..		

Select performance issue to see details.

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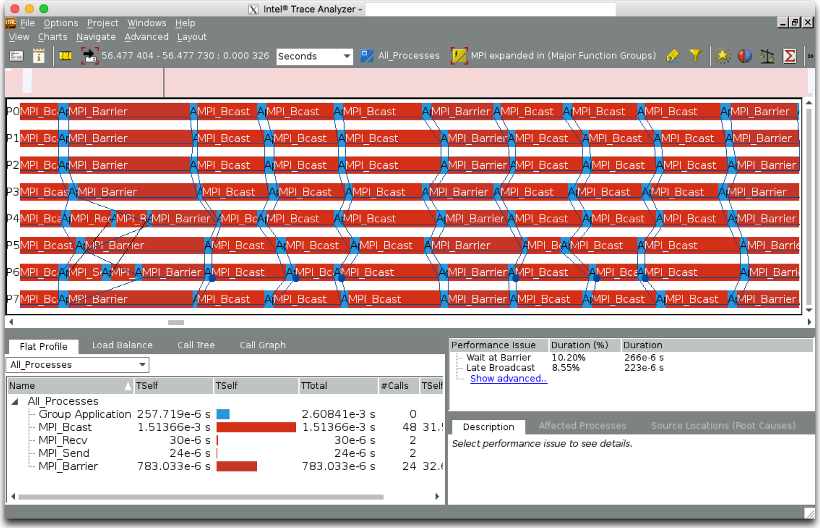
Detailed timeline



56.477 404 - 56.477 730 : 0.000 326 Seconds All_Processes MPI expanded in (Major Function Groups)

All_Processes

Name	TSelf	TSelf	TTotal	#Calls	TSelf
All_Processes					
Group Application	257.719e-6 s		2.60841e-3 s	0	
MPI_Bcast	1.51366e-3 s		1.51366e-3 s	48	31.
MPI_Recv	30e-6 s		30e-6 s	2	
MPI_Send	24e-6 s		24e-6 s	2	
MPI_Barrier	783.033e-6 s		783.033e-6 s	24	32.

Performance Issue	Duration (%)	Duration
Wait at Barrier	10.20%	266e-6 s
Late Broadcast	8.55%	223e-6 s
Show advanced..		

Select performance issue to see details.

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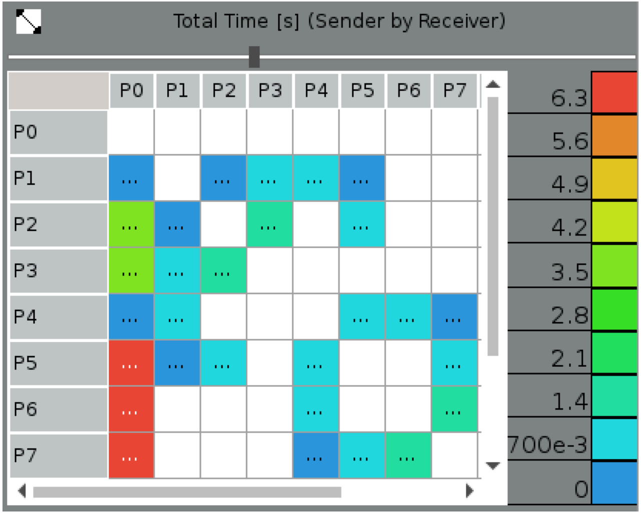
Message pattern



Total Time [s] (Sender by Receiver)

	P0	P1	P2	P3	P4	P5	P6	P7
P0								
P1	...		...	...	...	...		
P2	...	...		...		...		
P3	...	...	...					
P4	...	...				...	...	...
P5	...	...	...		...			...
P6	...				...			...
P7	...				...	...	...	

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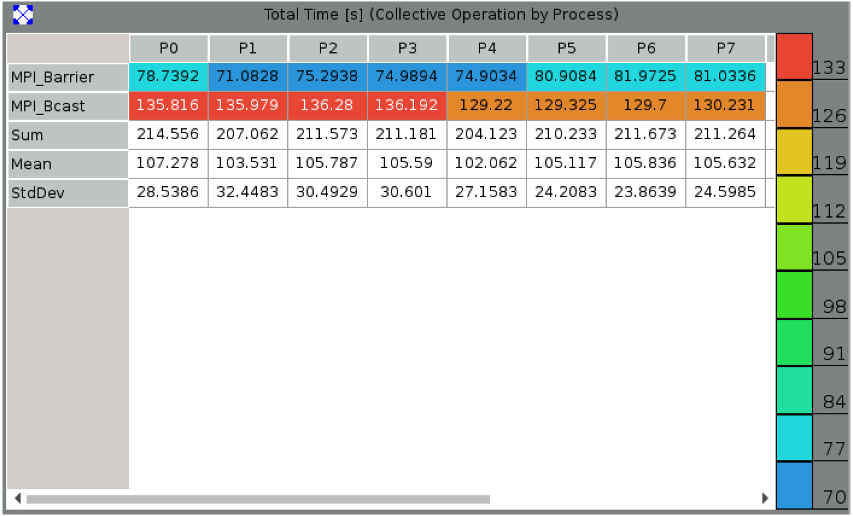
Reductions summary



Total Time [s] (Collective Operation by Process)

	P0	P1	P2	P3	P4	P5	P6	P7
MPI_Barrier	78.7392	71.0828	75.2938	74.9894	74.9034	80.9084	81.9725	81.0336
MPI_Bcast	135.816	135.979	136.28	136.192	129.22	129.325	129.7	130.231
Sum	214.556	207.062	211.573	211.181	204.123	210.233	211.673	211.264
Mean	107.278	103.531	105.787	105.59	102.062	105.117	105.836	105.632
StdDev	28.5386	32.4483	30.4929	30.601	27.1583	24.2083	23.8639	24.5985

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- If that fails, consider more advanced MPI features

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```
call MPI_File_Open(comm, 'con', MPI_Mode_Rdonly, &
MPI_Info_Null, mpi_fh)
call MPI_File_Set_View(mpi_fh, 0_8, MPI_Real, mpiio_type, &
"native", MPI_Info_Null)
call MPI_File_Read_All(mpi_fh, theta, &
3 * ksizex_l * ksizey_l * ksizet_l, &
MPI_Real, status)
call MPI_File_Close(mpi_fh)
```

Subarray types

```
subroutine init_single_halo_type_4(direction, position, size4, datatype, typet)
  integer, intent(in) :: direction, position, size4
  type(MPI_Datatype), intent(in) :: datatype
  type(MPI_Datatype), intent(out) :: typet
  integer, dimension(4) :: sizes, subsizes, starts
  sizes = (/ ksizex_l + 2, ksizey_l + 2, ksizet_l + 2, size4 /)
  subsizes = (/ ksizex_l, ksizey_l, ksizet_l, size4 /)
  subsizes(direction+1) = 1
  starts = (/ 1, 1, 1, 0 /)
  starts(direction+1) = position
  call MPI_Type_Create_Subarray(4, sizes, subsizes, starts, &
                   MPI_Order_Fortran, datatype, typet)
  call MPI_Type_Commit(typet)
  return
end subroutine init_single_halo_type_4
```

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- Also need `MPI_Wait/MPI_WaitAll`
- Speedup achieved will depend on architecture/communications fabric combination
- Collectives planned for MPI 3.2, e.g. `MPI_AllReduce_Init`

Thanks for listening!

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