

Western

Real time display with Gnuplot

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Outline



- The needs compute and visualize
- The workflow and requirements real time display
- Computing and visualizing calling third party software directly from the application
- Computing and visualizing separate, asynchronous processes
- Computing and visualizing synchronized processes via a pipe
- Other options





The needs



The needs

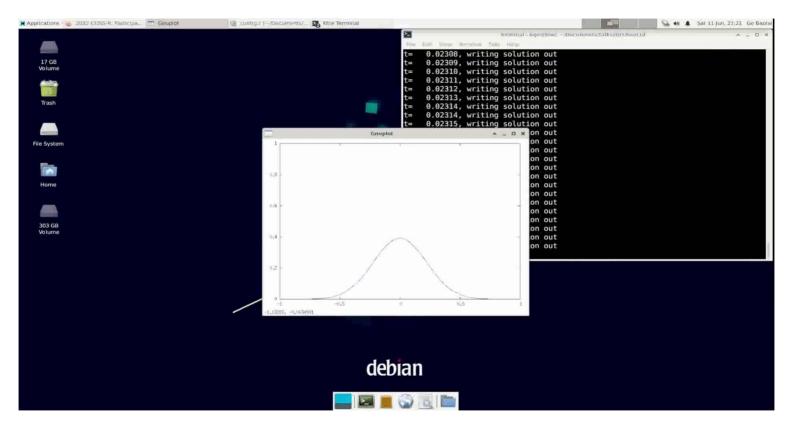


- Experimenting an algorithm, a configuration.
- Needs to check the intermediate results, stop the computation if things go unexpectedly.
- Debugging by visualization, especially useful for physics and mathematical problems.



The needs – checking solutions

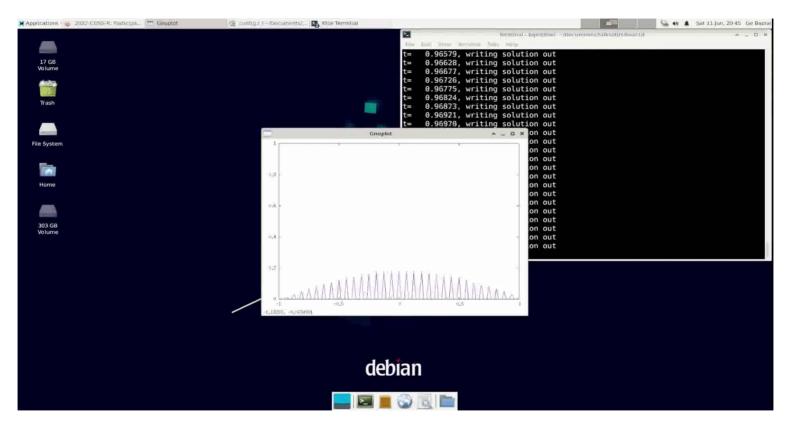






The needs – checking solutions







The needs – visual debugging



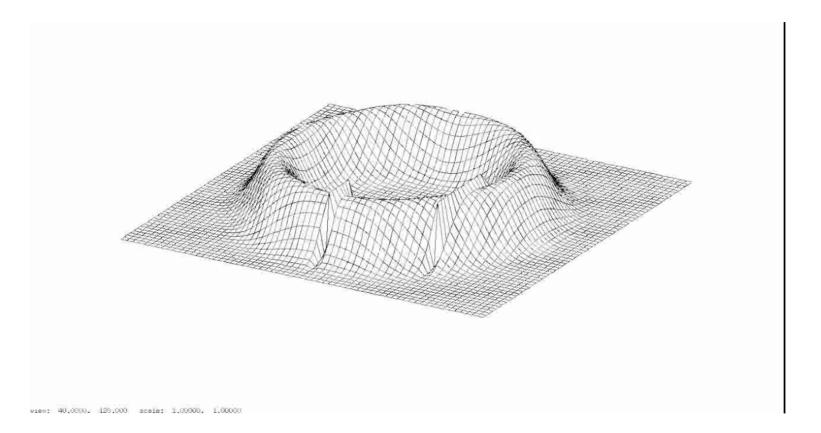




June 15, 2022

The needs – visual debugging





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The workflow and requirements for real time display



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The workflow and requirements - methods

Push

- The graphical program (e.g. Gnuplot) is fed with data stream from the application program.
- It generates the plot synchronously.
- Calling a third party tool directly, e.g. PGPLOT from within the application program belongs to this category.
- Other options include, e.g. using a pipe that is managed by the operating system.

Pull

- The graphical program does not know when the data arrives.
- It checks periodically if the data file has become available.
- When the data is ready, it generates the plot.
- This is the common way.



R C N F T™

The workflow and requirements - expectations

- The display is platform independent.
- The display of the output is smooth.
- No missing "frames" or corrupted graphs.
- Easy to implement.
- Do not slow down the compute process.







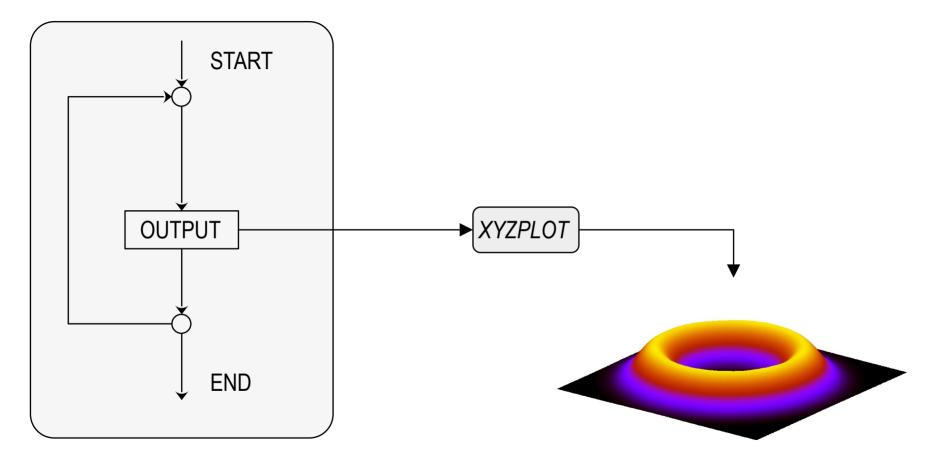
Computing and visualizing via

calls to third party graphics functions



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Compute & display – synchronously via 3rd party functions / s H A R C N E T





Compute & display – synchronously via 3rd party functions / s H A R C N E T*

Using PGPLOT

! Initialize PGPLOT

```
call pgbeg(0, "/xs", 1, 1)
call pgask(0)
call pgenv(xlim(1), xlim(2), 0., 1.0, 0, 0)
call pgline(n,x(1),uold(1))
```

```
do step = 1, num_steps
```

! Compute the solution

```
do concurrent (i=1:n)
unew(i) = (1.0 - 2^{r})^{uold(i)} + r^{uold(i-1)} + uold(i+1))
end do
```

! Output the current solution

```
if (mod(step, output_steps) == 0) then
  call pgeras
  call pgline(n,x(1),unew(1))
endif
```





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14 / 31

- PLplot
- pyplot-fortran
- f03gl
- Gnuplot-iostream-interface
- MathGL
-

Compute & display – synchronously via 3rd party functions // s H A R C N E T*

The workflow

- The compute process produces an output and calls a third party routine, e.g. PGPLOT, to produce (persistent) display.
- **Pros:** Synchronized.
- Cons: The graphical display usually tied to the language. Not portable, not so easy to customize.

Meet the requirements?

- The graphical routine call blocks, is able to read the output from the main with no loss or corrupted data, until the plot is generated.
- To draw (frame of) plot within the same figure window, making animation in real time possible.





Computing and visualizing via

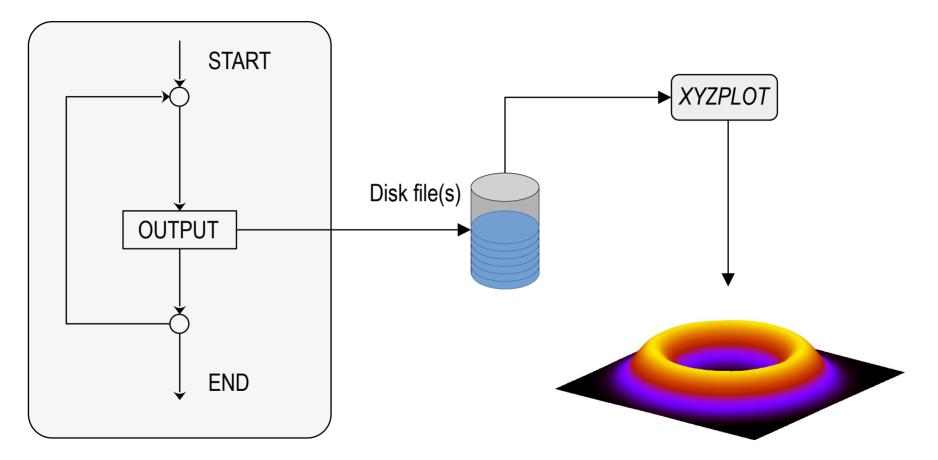
separate, asynchronous processes



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Compute & display – asynchronously









© bge@crow -/Documents/talks/dir/heat2d Saving solution at t=0.000113379 to file output.45 Saving solution at t=0.000115898 to file output.45 Saving solution at t=0.000120937 to file output.47 Saving solution at t=0.00012937 to file output.48 Saving solution at t=0.00012976 to file output.50 Saving solution at t=0.000128476 to file output.51 Saving solution at t=0.00013505 to file output.51 Saving solution at t=0.00013535 to file output.52 Saving solution at t=0.000136054 to file output.53 Saving solution at t=0.000136054 to file output.54 Saving solution at t=0.000141093 to file output.55 Saving solution at t=0.000141093 to file output.56 Saving solution at t=0.000141093 to file output.56 Saving solution at t=0.000146133 to file output.57 Saving solution at t=0.00015611 to file output.58 Saving solution at t=0.00015611 to file output.60 Saving solution at t=0.000156211 to file output.60 Saving solution at t=0.000156211 to file output.63 Saving solution at t=0.000162769 to file output.64 Saving solution at t=0.00016873 to file output.64 Saving solution at t=0.000168769 to file output.64 Saving solution at t=0.000168808 to file output.65 Saving solution at t=0.000168808 to file output.64 Saving solution at t=0.00017837 to file output.65 Saving solution at t=0.00017837 to file output.64 Saving solution at t=0.000178375 to file output.65 Saving solution at t=0.000178375 to file output.70 Saving solution at t=0.000178375 to file output.70 Saving solution at t=0.000178375 to file output.70 Saving solution at t=0.000178375 to file output.71 Saving solution at t=0.000178375 to file output.72 Saving solution at t=0.000178375 to file output.73 Saving solution at t=0.000178375 to file output.74 Saving solution at t=0.000178375 to file output.74 Saving solution at t=0.000178375 to file output.75 Saving solution at t=0.000178375 to file output.72 Saving solution at t=0.000178375 to file output.73 Saving solution at t=0.000178375 to file output.73 Saving solution at t=0.000178375 to file output.73 Saving solution at t=0.0					
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Gnuplot script

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"heat2d_mplots.plt" – Generate multiple plots in a same graph set view 30,104,1,1 unset colorbox set hidden3d

num_output = ARG1 # Version 5+, taking ARG1 to ARG9

do for[i=1:num_output] { splot 'output.'.i using 1:2:3 with lines It -1 pause -1

```
pause -1 "Press ENTER to exit"
```

The Shell command

gnuplot -c heat2d_mplots.plt 200

demo

Western June 15, 2022

SHARCNET"

The workflow

- This is the most common approach.
- The compute process produces snapshots of output periodically and stores them into a sequence of files, which can be processed asynchronously and examined in postprocessing.
- We use a separate process to view the results in sequence with some delay.
- **Pros:** No change in the compute program, the program knows nothing about graphical display.
- Cons: Many many files need to be saved in order to show a relatively long computed solution.

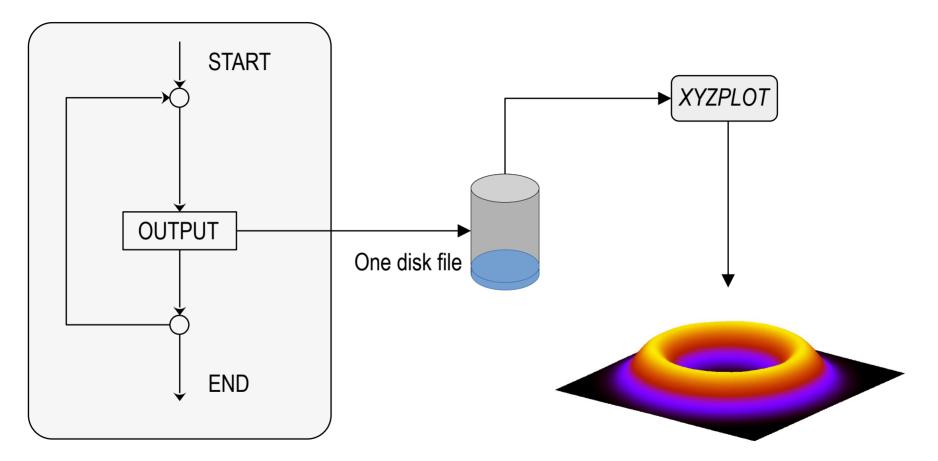
Meet the requirements?

- The graphical program reads data for each frame from a separate file, intact, so no loss.
- The graphical program can generate multiple frames within the same figure window, make animation in real time possible.



Compute & display – asynchronously









The application code

// During the iteration, when its time to output

```
if (NULL == (fp = fopen("output.dat", "w")))
{
    printf("Can't open file %s: %s", fname, strerror(errno));
    exit(0);
}
printf("Saving solution at t=%g to file %s\n", t, fname);
for (int j = 1; j <= nyg; j++)
{
    for (int i = 1; i <= nxg; i++)
        fprintf(fp, "%f %f %f\n", xc[i], yc[j], unew[j][i]);
    fprintf(fp,"\n");
}</pre>
```

icount++;
fclose(fp);

Gnuplot script

"heat.plt" - Plot one frame at a time

set view 30,104,1,1 unset colorbox set hidden3d

splot 'output.dat' using 1:2:3 with lines It -1 reread

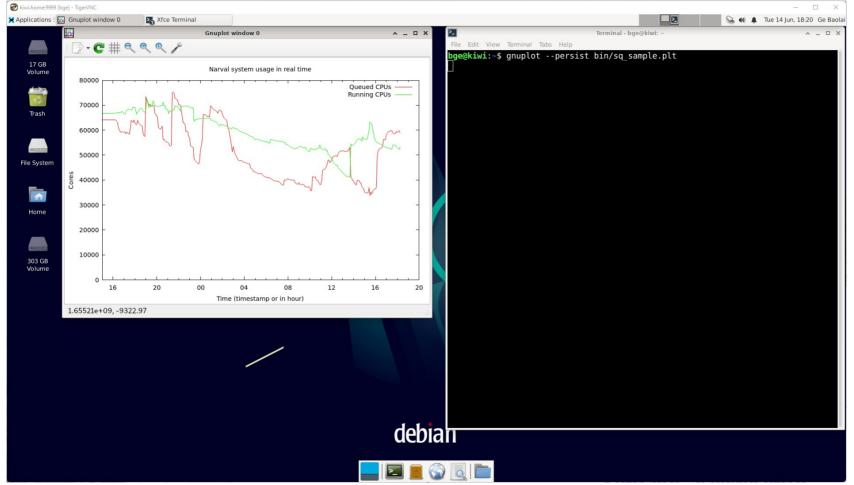
The Shell command

heatc | gnuplot -persist heat.plt



demo

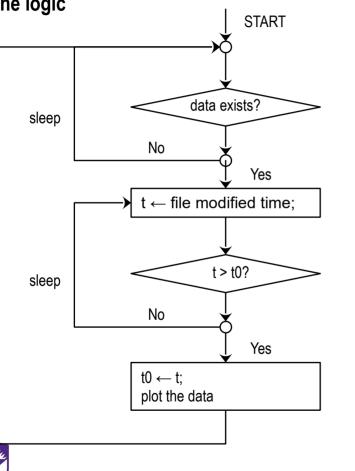












Gnuplot scripts – one graph window, persistent

```
# "sample_loop.plt" - The looper for sq_sample.plt.
datafile = "data.csv"
```

```
t = system("expr `date +%s` - `stat -c %Y sq data.csv`")
if (t == t0) {
  pause 30
  reread
t0 = t
```

plot datafile using 1:4 with lines It rgb "red" title "Queued CPUs", "" using 1:5 with lines It rgb "green" title 'Running CPUs' reread

"sample.plt" - The control script t0 = 0load 'sample_loop.plt'

The Shell command

gnuplot -persist sample.plt



SHARCNET[™]

The workflow

- The compute process produces a snapshot of output at a time periodically, either to the standard output or a file
- A separate, e.g. Gnuplot process, reads the output results as input and plots it as a "frame" in a sequence of display.
- Pros: No change in the compute program. Display control is done separately.
- **Cons:** The compute program and the graphical program run concurrently, the graphical program may read the output file that is just truncated to zero for writing by the program. So we could get a corrupted frames.

Meet the requirements?

- The graphical program can read the output from the compute program.
- The graphical program can generate multiple frames within the same figure window, make animation in real time possible.





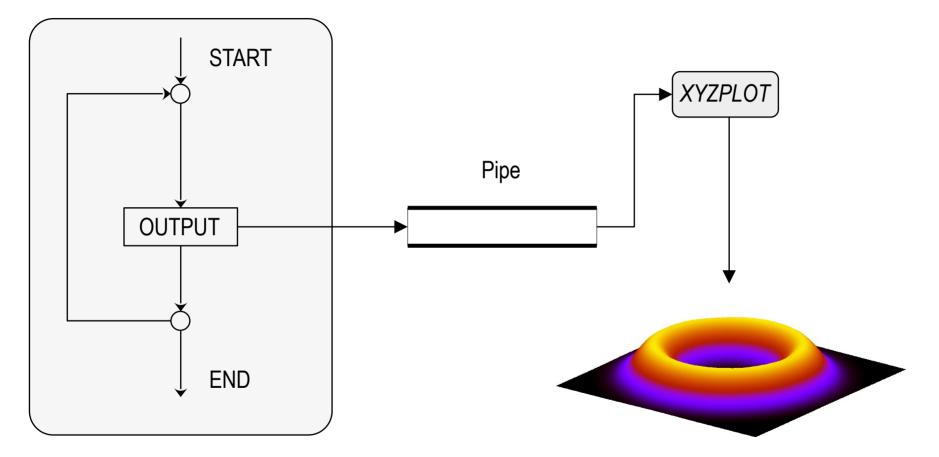
Computing and visualizing synchronized via a pipe



June 15, 2022

Compute & display – synchronized via a pipe







Compute & display – synchronized via a pipe



The application code

// Open a pipe via system call popen(), creating a process of Gnuplot
FILE *fp=NULL;
fp = popen("gnuplot -persist","w");

```
// Read Gnuplot setup file from plot_cfg_file and write to the pipe
FILE *ff=NULL;
ff = fopen("heat_gnuplot.cfg","r");
```

....

```
// During the iteration, when generating the output, write the output to the pipe
```

```
fprintf(fp, plot_command); // Write "splot - using 1:2:3 with pm3d"
for (int j = 1; j <= nyg; j++)
{
    for (int i = 1; i <= nxg; i++)
        fprintf(fp, "%f %f %f\n", xc[i], yc[j], unew[j][i]);
    fprintf(fp,"\n");
}</pre>
```

```
fprintf(fp,"e\n"); // Put an end mark to the stream
fflush(fp);
```

Gnuplot script – setup commands

```
# "heat_gnuplot.cfg" – Gnuplot setup file
```

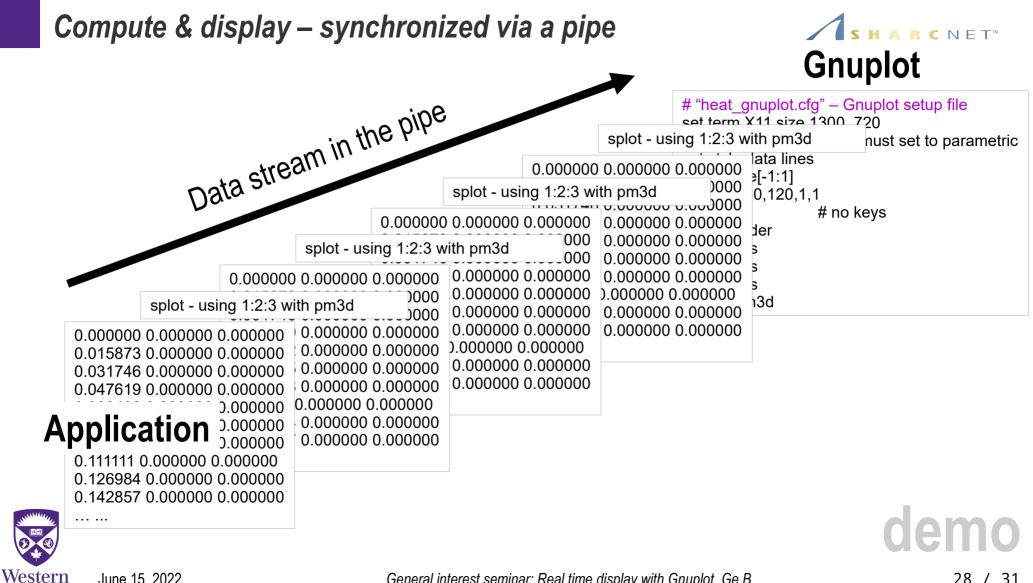
set term X11 size 1300, 720 unset parametric # must set to parametric set style data lines set zrange[-1:1] set view 40,120,1,1 set nokey # no keys unset border unset stics unset ytics unset ztics set hidden3d

The Shell command

heatc



demo



Compute & display – synchronized via a pipe



The workflow

- The compute process produces a snapshot of output at a time periodically, either to the pipe.
- A separate Gnuplot process reads the output results as input and plots it as a "frame" in the sequence of display.
- Pros: Compute and display are synchronized, graphical display is smooth. The data stream in the pipe is handled by the OS.
- Cons: The application program needs to open a pipe and close a pipe via system calls, which might not be explicitly supported, e.g. in Fortran. But that's it.

Meet the requirements?

- The graphical program can read the output from the compute program from the pipe. The data once in the pipe no longer affected by the compute program. So no loss.
- The graphical program can generate multiple frames within the same figure window, make animation in real time possible.



June 15, 2022

Summary



Requirements	Direct, using third party library	Asynchronous, separate processes	Synchronous, via pipe
Display is platform independent	Maybe	No	Yes*
The display of output is smooth	Yes	Maybe	Yes
No missing "frames" or corrupted graphs	Yes	Not guaranteed	Yes
Difficulty to implement	Moderate to difficult	Easy	Easy
Does not slow down the compute part	Maybe	Maybe	Maybe

* For Windows, WSL2 supports pipe.



References



- [1] SHARCNET training https://training.sharcnet.ca/
- [2] Gnuplot on github http://www.gnuplot.info/

