Project 3

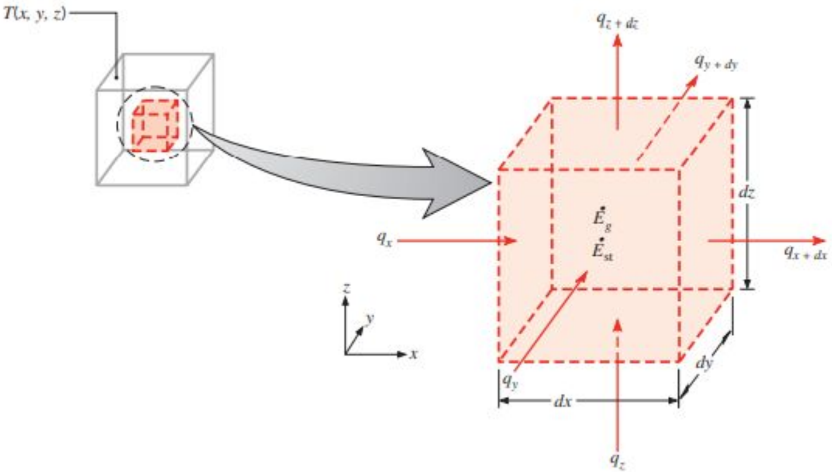
Performance Analysis of different Parallelization Frameworks on Heat Flow Application (OpenACC vs MPI)

By: Justin Hafling, Hans Walker, and Hasnain Abdur Rehman

Heat Flow Equation

$$\frac{\partial}{\partial x}\left(k\frac{\partial T}{\partial x}\right)+\frac{\partial}{\partial y}\left(k\frac{\partial T}{\partial y}\right)+q=\rho c_p\frac{\partial T}{\partial t}$$

k	thermal conductivity, $W/m \cdot K$
ρ	mass density, kg/m^3
c_p	specific heat at constant pressure, $J/kg \cdot K$



Fourier's Law of Cooling

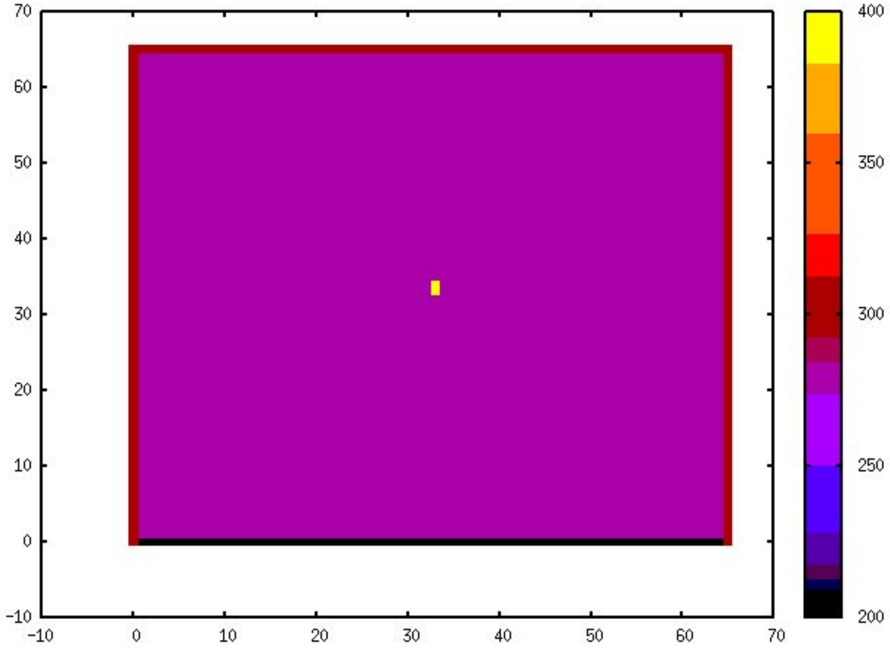
```
qx_conv_left = K * (T[x][y-1] - T[x][y]) / D_X;
qx_conv_right = K * (T[x][y] - T[x][y+1]) / D_X;

qy_conv_up = K* (T[x][y] - T[x-1][y]) / D_Y;
qy_conv_down = K* (T[x+1][y] - T[x][y]) / D_Y;
```

```
//                  X-Direction Flux              Y-DIrection Flux        Internal Generation
T_DELTA[x][y] = (qx_conv_left - qx_conv_right +  qy_conv_down - qy_conv_up + Q[x][y]) / (RHO * C_P);
```

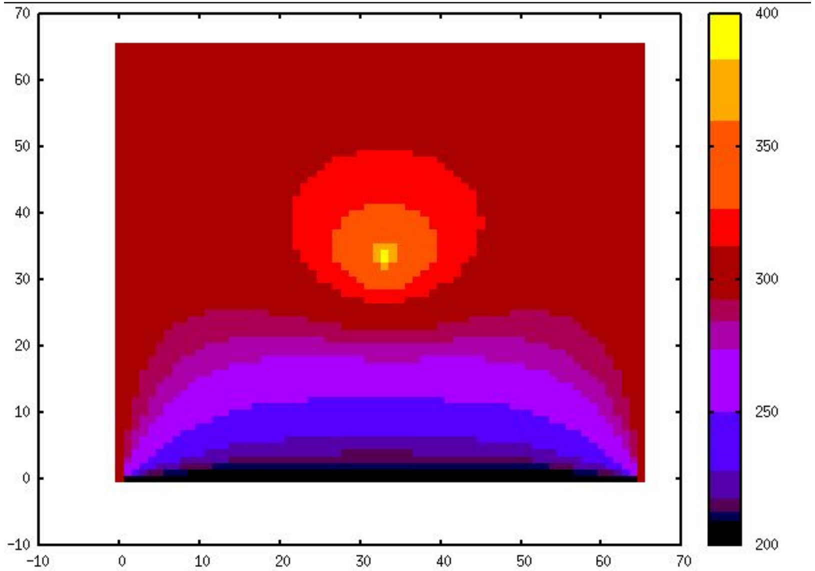
Initial Conditions

- Bottom Wall: 200K
- Other Walls: 300K
- Central Box (2x2): 400k
- Else: 273.15 K

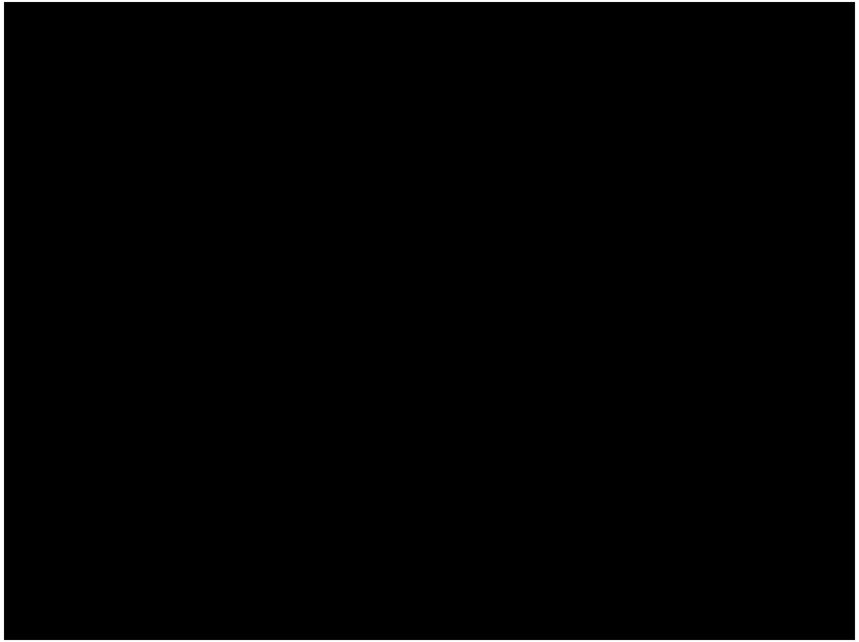


Stopping Conditions

The Temperature Mapping was considered to converge
When the sum of the changes of temperature from one
Iteration to the next was less than 0

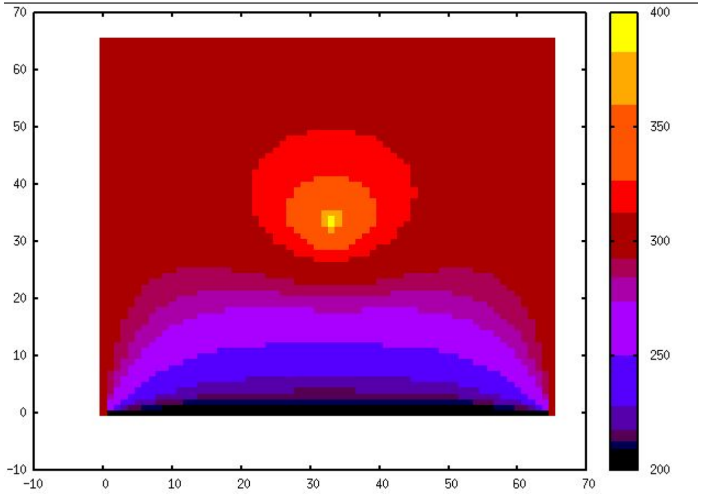


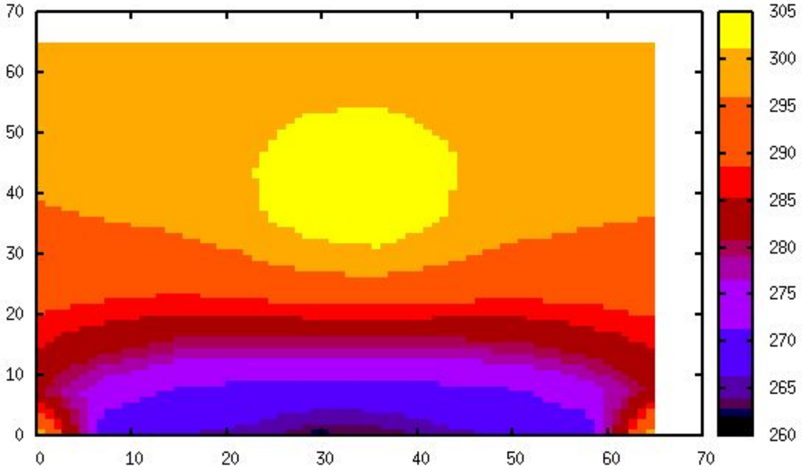
Animation



```
plot for[i = 0:7] "".i."_Heatmap.dat" using 2:1:3 with image notitle
pause 3
reread
```

Observation

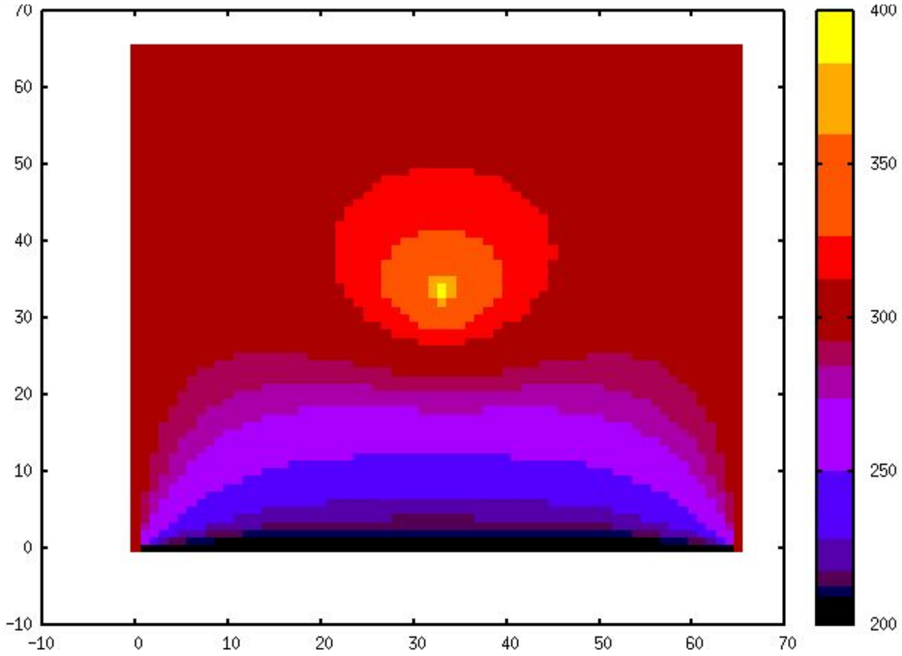




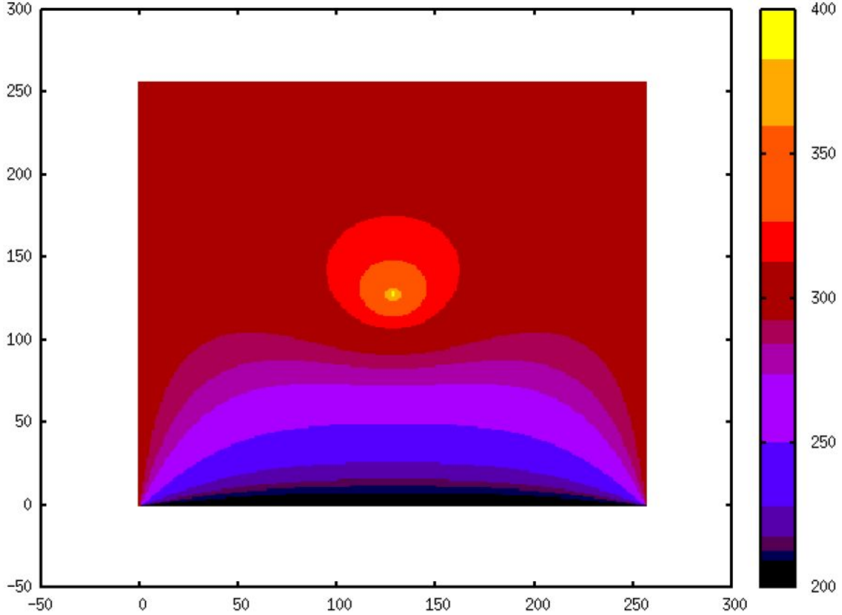
Gnuplot (Plot) vs Gnuplot (splot)

(For Heatmaps)

More Plots



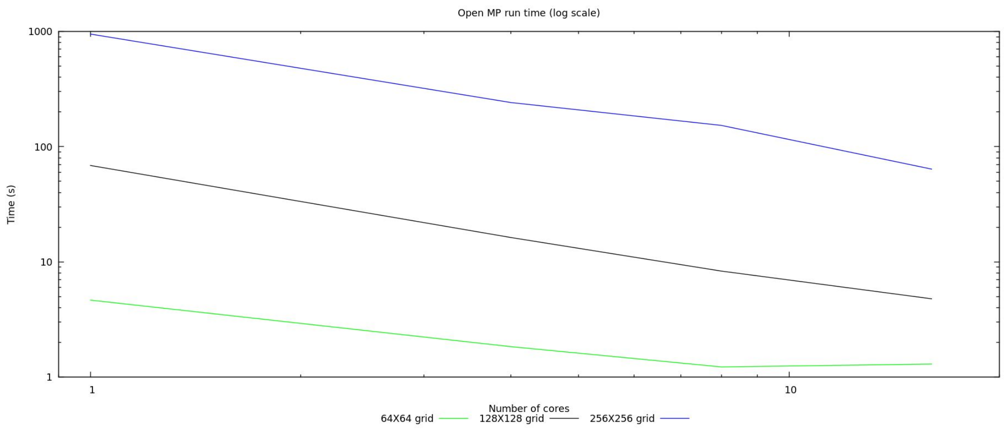
64x64

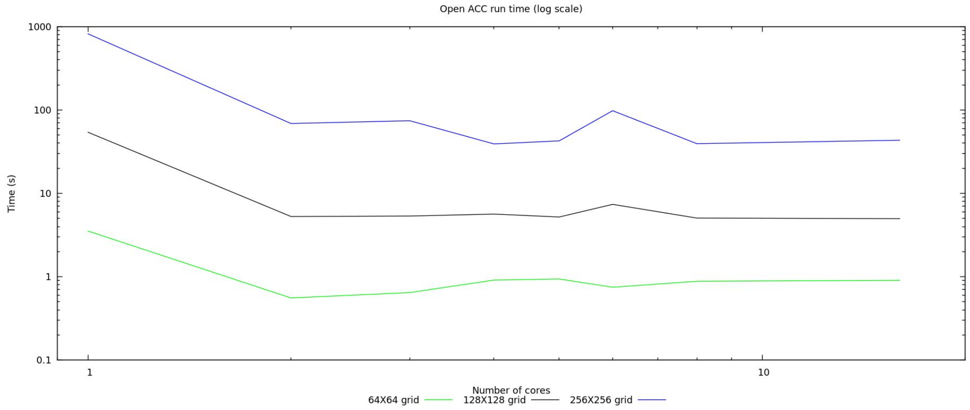


256x256

Time Plots

-A trend exists, but not necessarily linear
-ACC seems to converge, while MP doesn't





Closing Remarks

-It seems clear that open ACC was faster especially in the mid amount of of processors, but hit a ceiling

-Open MP gave a bit more control over data, giving it a higher ceiling

-Open ACC deals with a lot more things on the backend, making it easier to get a better performance