Understanding Supernovae with Condor

Bang!

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SN 1006
Type I Supernova
May 1, 1006

Accretion of matter onto a companion star.
Cassiopeia A,
A type II supernova
November 11, 1572

Collapse of a massive star
Heavier than $He$, normal star, Heavier than $Fe$, supernova
How does this happen?

• Star becomes too massive to support itself
• Gravity finally wins, compression starts
• Outer layers ignite, inner layers undergo complex nuclear reactions
• Inward shock compresses core
• Outward shock expels heavy elements
• http://www.youtube.com/watch?v=grwpeEyt_98&NR=1
How do you simulate this?

• Start with a model star, choose some mass, composition, density etc.

• Follow the collapse in small time steps calculating the state of the matter at many cells of the simulated star

• Given the temperature, pressure, free energy, etc. at each cell, propagate to the next time step.
So, why is that hard?

- All parts are hard but step 2 is hardest
- Matter under these conditions cannot be observed directly
- Nuclear reactions effect the state of matter, the state of matter effects the reactions
- Next time step gives you a different density, composition, free energy, etc.
The computational problem:

• Calculating the Equation of State at a particular set of values for temperature, density and composition takes from a few seconds to a few days.

• A large range of values is needed to simulate a supernova, for example, densities from $10^{-8}$ to 1.6 (in some units)

• The calculations require “smooth” behavior for self consistency.
How to solve it:

• Calculate the Equation of State once and for all up front.

• Partition the relevant range of input variables into a grid, sufficiently fine to allow reliable interpolation, coarse enough to finish in one graduate student lifetime (or less)

• EoS exists as a table of values at each value of \((T, \rho, \eta)\)
Where does Condor fit in?

- Each point is independent of all other points.
- There are many points (~2,000 initially), each calculable by a single processor task. (No MPI, OpenMP or any of that)
- The output from a calculation at a point is small (256 bytes with embedded indexing information and the answer)
Our Condor Pool

- Student Technology Center computers
- These are paid for by student fees, the students own them, there is high sensitivity to using them for non-student activities
- There are thousands of them, most in the flock
- Use them in a “cycle scavenging mode”
The constraints:

- Must use a single, non multicore, executable
- Must run on Windows OS
- Cannot require “large” input data or produce “large” amount of output data
- Will be terminated as soon as a user attempts to use the computer running the job (touches the mouse, for example)
How did we do it?

• Code was developed on a Linux workstation
• Mapped parameter space onto integers
• Built the executable with the GCC suite under cygwin
• Packaged it all up and copied it to the condor server head node
• Submitted a single job and…
Executable      = dirr_single.exe
Universe        = vanilla
Requirements = ( Arch == "INTEL" && Opsys == "WINNT60" )
should_transfer_files   = YES
when_to_transfer_output = ON_EXIT

transfer_input_files   = cygwin1.dll, dir_high.dat, dir_low.dat, dirr_single.exe.local

notification    = never

Arguments = -j2067
Queue
Arguments = -j10690
Queue
Arguments = -j355
Queue
Arguments = -j3514
Queue
...

Condor Week, Madison WI
Our Condor experience

• Ran ~1,700 jobs over the 4’th of July weekend
• It was my first experience building executables under any flavor of Windows
• It was my first experience using Condor antwhere
• It was easy
• Worked like a charm, absolutely painless
What else do we do?

- The constraints are rather severe so our use is rather limited
- Have run a few hundreds of batches of jobs
- Almost all of these are rendering jobs, made a very nice, HiRes movie of a beating heart
- Some animations for local PBS station