Performance Analysis of DroughtHPC and Holistic HPC Workflows

Yasodha Suriyakumar  
yasodhan@pdx.edu  
Karen L. Karavanc  
karavan@pdx.edu  
Hamid Moradkhani  
hmoradkhani@ua.edu

Goals

- Analyze the performance of DroughtHPC [1], a drought prediction application developed at Portland State University
- DroughtHPC improves prediction accuracy for a target geographical area; uses data assimilation techniques that integrate data from hydrologic models, and satellite data
- Uses variety of data: soil conditions, snow accumulation, vegetation layers, canopy cover and meteorological data
- Scale the application to do finer-grained simulations, and to simulate a larger geographical area

Implementation

- Land surface of the target geographical area is modeled as a grid of uniform cells, and simulation divides it into jobs, with group of 25 cells in each job
- For a job that simulates 50 meteorological samples and one month time period, input data size is 144.5 MB, with the satellite data consuming 132 MB
- Runtime for a job on single-node is approximately two hours with the initial Python prototype

Results: Single Node

Runtime data of DroughtHPC (with VIC) for 50 meteorological samples and one month simulation on a single node (8 cores)

<table>
<thead>
<tr>
<th>Number of jobs (group of 25 cells)</th>
<th>Minimum runtime (hours: minutes)</th>
<th>Maximum runtime (hours: minutes)</th>
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<tbody>
<tr>
<td>1</td>
<td>2:21</td>
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<tr>
<td>2</td>
<td>1:54</td>
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<td>8</td>
<td>1:48</td>
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<tr>
<td>12</td>
<td>2:42</td>
<td>2:44</td>
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</tbody>
</table>

Observations

- No single performance tool characterizes the calling pattern / interactions between Python and VIC
- Profiling does not focus attention to the number of files or frequency of file creation/access
- Manual integration of data from multiple performance tools is time-consuming: Python cProfile, Valgrind, Strace system utility, etc.

Methodology

Evaluate sequential single-cell simulation performance
Analyze timing and memory footprint of hydrology models

For parallel single-node performance, study the correlation between runtime and the problem size

For parallel multi-node performance in a Linux cluster, analyze effects of interference from other processes

Summary and Future Work

- Single-cell simulations: bottleneck is the overhead of the VIC hydrologic model call from Python
- Parallel single-node performance:
  - The best fit on our platform is one job per logical core;
  - We explored changes to VIC for Intel Xeon Phi
  - We are developing a version of VIC that eases integration with individual science codes such as data assimilation
  - Multi-node simulations with MPI: bottleneck is the filesystem access pattern
- We designed PPerfG for visualizing Holistic HPC Workflows
- We implemented a prototype of PPerfG

References


PPerfG

- PPerfG: A Visualization Tool for Holistic HPC Workflows for use in performance diagnosis
- Captures the data movement behavior between storage layers, and between different stages of an application
- Challenges: Determining best metrics, and efficient measurement techniques
- Status: initial prototype developed

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