Performance Analysis of DroughtHPC and Holistic HPC Workflows

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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

- Application is written in Python, and uses two hydrologic models VIC [2] written in C, and PRMS [3] written in FORTRAN and C
- Land surface of the target geographical area is modelled as 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

Methodology

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

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

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

Results: Single Node

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

Number of jobs (group of 25 cells)	Minimum runtime (hours: minutes)	Maximum runtime (hours: minutes)
1	2:21	2:21
2	1:54	1:55
4	1:49	1:50
8	1:48	1:50
12	2:42	2:44

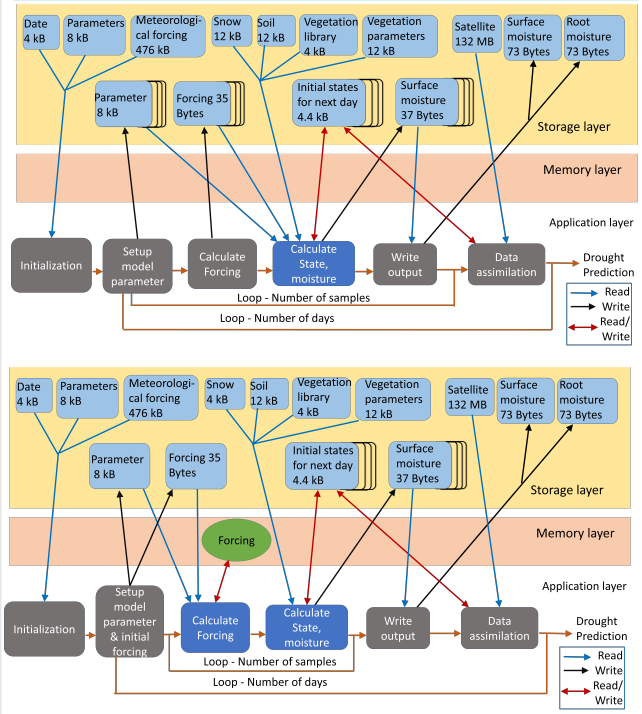
Observations

- 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.

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

Holistic HPC Workflows: DroughtHPC



2 Holistic workflow diagrams of DroughtHPC: Files accessed in simulation of a single cell, with multiple meteorological data (Number of samples), and time period (Number of days). Gray sections refer to Python code, and blue refers to the hydrologic model . Top: VIC accesses 57 files in total in each call. Bottom: Hydrologic model (VIC) code is changed to minimize forcing data's movement between storage layers, and reduce invocation cost

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

References

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