Integrated Parallelization of Computations and Visualization for Large-scale Applications

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Problem

Simultaneous visualization of the simulation data can reduce the end-to-end simulation-visualization time.

High simulation rate, high I/O bandwidth and low network bandwidth can lead to :-

- Rapid accumulation of data in stable storage
- Stalling of simulation
- Low temporal resolution of visualization

Impact of resource constraints

Disk Space	Network Bandwidth	Disk is full in
100 TB	1 Gbps 10 Gbps	8 hours 12 hours
500 TB	1 Gbps 10 Gbps	41 hours 60 hours

Weather simulation of grid size 4486 x 4486 points, 10 km resolution, execution on 16,384 cores with 1.2 seconds of execution time per time step, and I/O bandwidth of 5 GBps

Contributions

An adaptive integrated steering (INST) framework that simultaneously performs simulations and continuous online remote visualization of critical weather applications in resource-constrained environments

Features of INST

- Smooth simulation despite resource constraints
- Reconciling algorithmic and user-driven steering
- Efficient online visualization

LP formulation of Decision Algorithm

Objective – Minimize simulation time

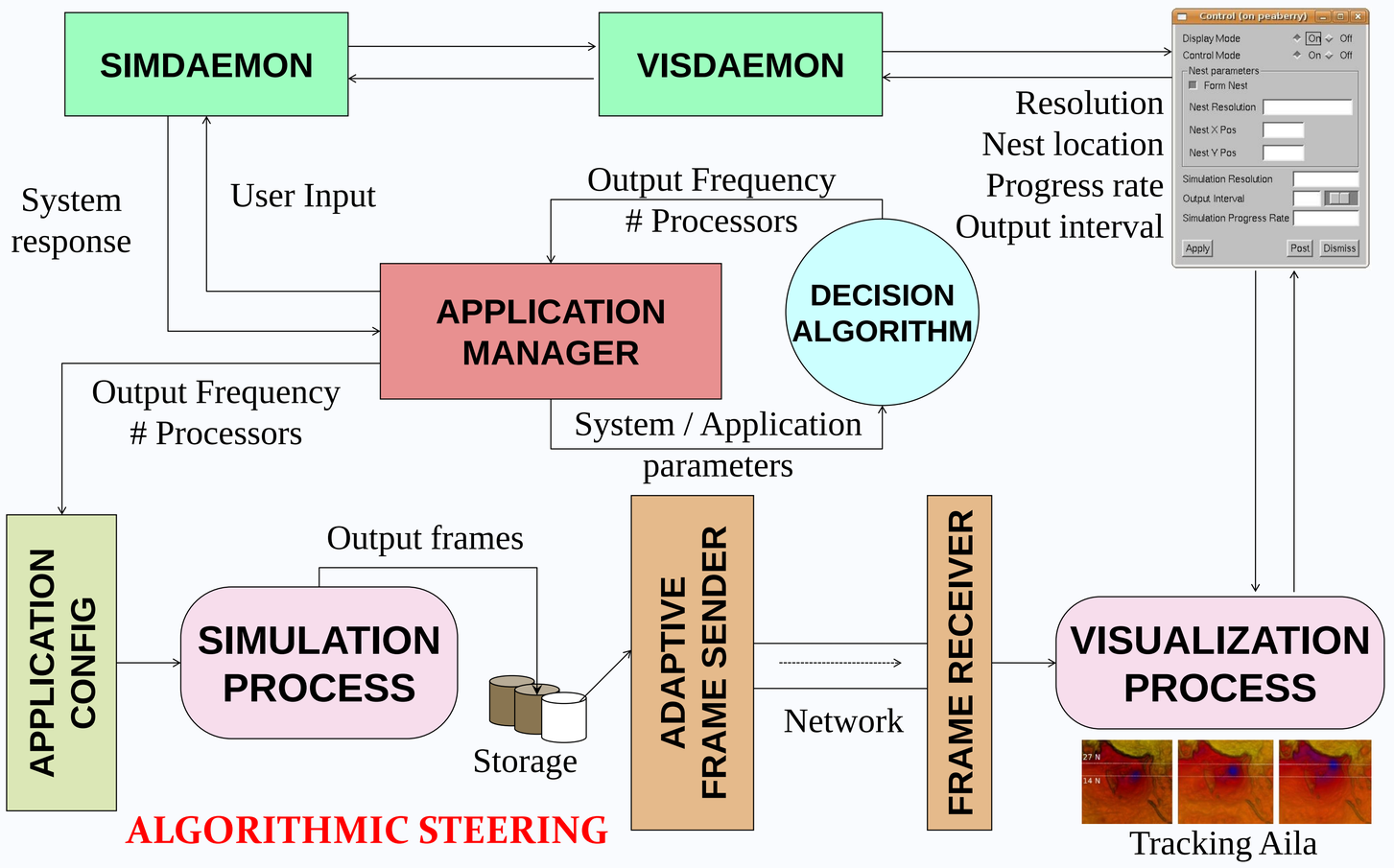
Constraints
- Disk space
- Network and I/O bandwidth
- Minimum progress rate

5 non-linear constraints rewritten as 5 linear constraints and one linear objective function

Output
Number of processors and Output frequency

References

- "InSt: An Integrated Steering Framework for Critical Weather Applications", Preeti Malakar, Vijay Natarajan, Sathish Vadhiyar, ICCS 2011, Singapore, June 2011.
- "An Adaptive Framework for Simulation and Online Remote Visualization of Critical Climate Applications in Resource-constrained Environments", Preeti Malakar, Vijay Natarajan, Sathish Vadhiyar, SC 2010.
- "An Integrated Simulation and Visualization Framework for Tracking Cyclone Aila", Preeti Malakar, Vijay Natarajan, Sathish S. Vadhiyar, Ravi S. Nanjundiah, Student Research Symposium, HiPC 2009.



INST: Adaptive Integrated Steering Framework

Efficient Online Visualization

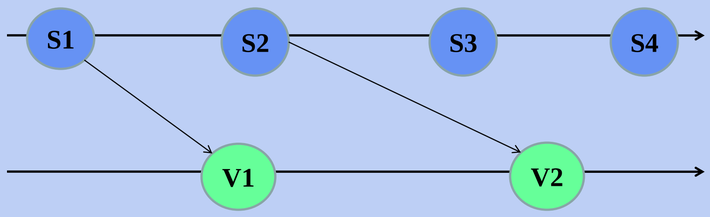
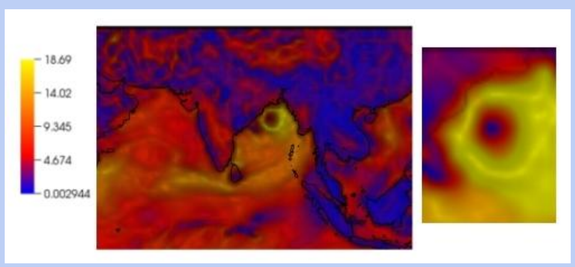


Illustration of increasing lag between simulation and visualization times

- High simulation speed and low network bandwidth can lead to lag-accumulation
- Adaptive algorithm to send representative frames can reduce lag

Visualization of region of interest



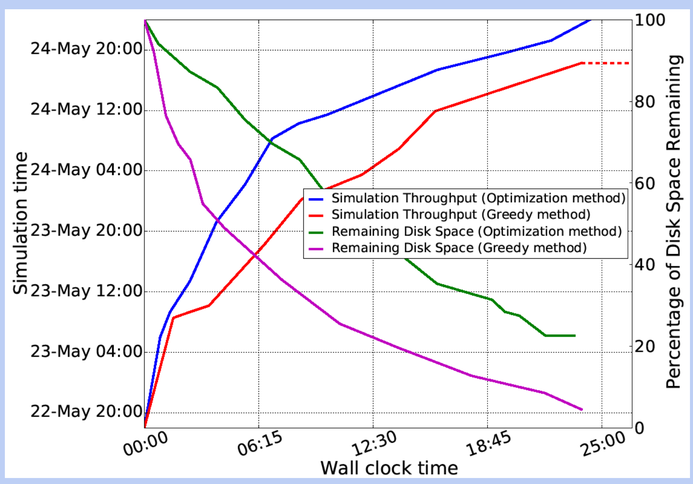
Visualization of nested high resolution simulation

Results

Simulation using WRF and Visualization using VisIt

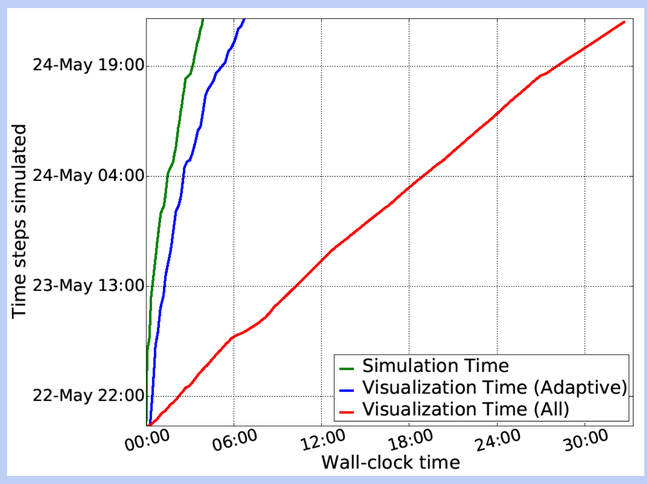
Simulation Configuration	Disk Space	Simulation-visualization network bandwidth	Maximum #cores
fire: AMD Opteron 2218 cluster	180 GB	56 Mbps	48
ggblr: Intel Xeon cluster	200 GB	16 Mbps	80
kraken: AMD Opteron processors (Istanbul)	500 TB	1.1 Mbps	288

- Objective: Smooth simulation and visualization
- Approach: Optimization based on resource constraints



Simulation progress and disk usage

- Objective: Reduce simulation-visualization lag
- Approach: Select representative frames



Simulation and visualization times

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