Differential Analysis with HPCToolkit

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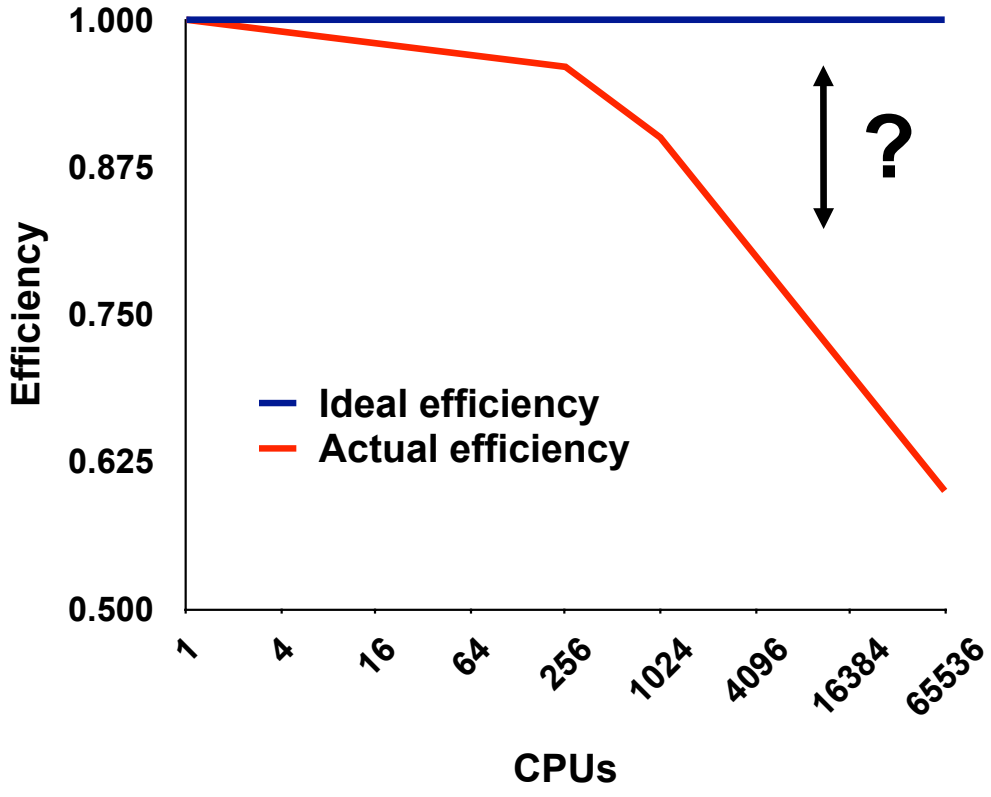
The Problem of Scaling



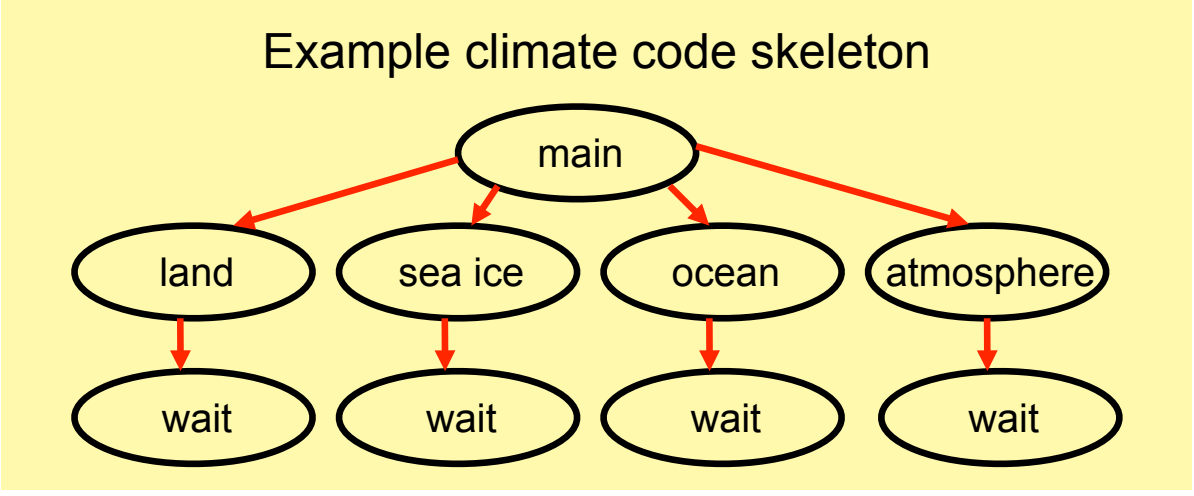
Note: higher is better

Goal: Automatic Scaling Analysis

- Pinpoint scalability bottlenecks
- Guide user to problems
- Quantify the magnitude of each problem
- Diagnose the nature of the problem

Challenges for Pinpointing Scalability Bottlenecks

- **Parallel applications**
  - — modern software uses layers of libraries
  - — performance is often context dependent



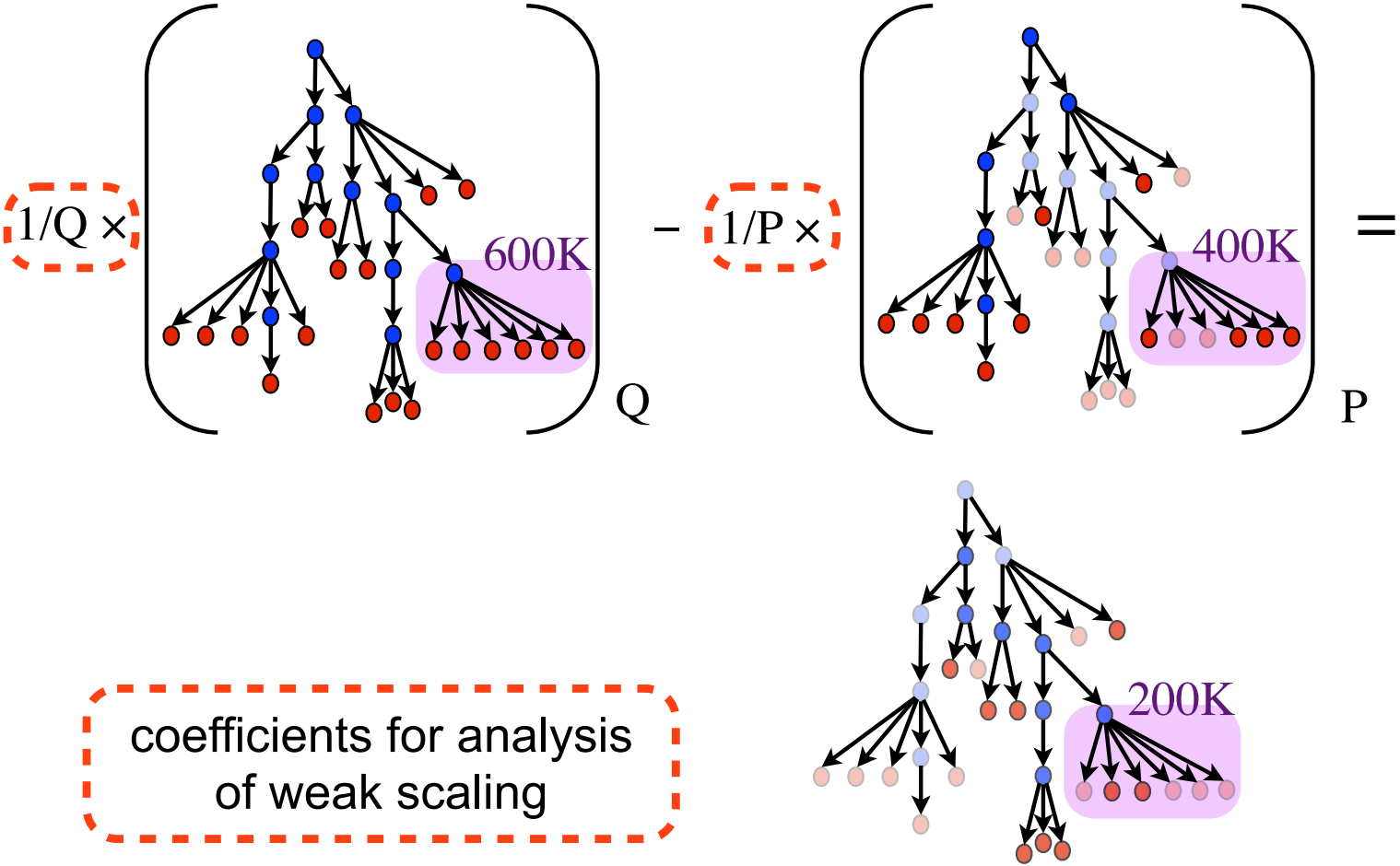
- **Monitoring**
  - — bottleneck nature: computation, data movement, synchronization?
  - — 2 pragmatic constraints
    - – acceptable data volume
    - – low perturbation for use in production runs

Performance Analysis with Expectations

- You have performance expectations for your parallel code
  - strong scaling: linear speedup
  - weak scaling: constant execution time

- Put your expectations to work
  - measure performance under different conditions
    - e.g., different levels of parallelism or different inputs
  - express your expectations as an equation
  - compute the deviation from expectations for each calling context
    - for both inclusive and exclusive costs
  - correlate the metrics with the source code
  - explore the annotated call tree interactively

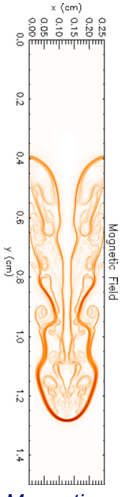
Pinpointing and Quantifying Scalability Bottlenecks



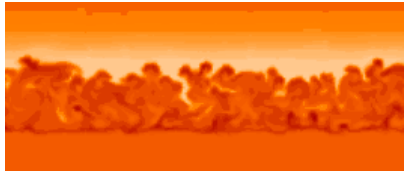
coefficients for analysis of weak scaling

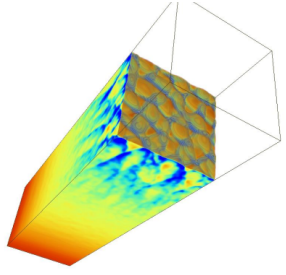
Scalability Analysis Demo

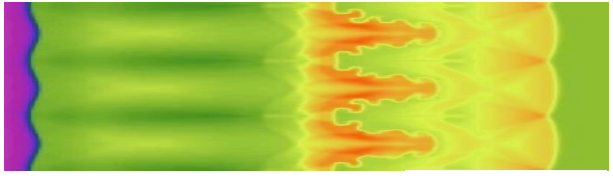
Code: University of Chicago FLASH
Simulation: white dwarf detonation
Platform: Blue Gene/P
Experiment: 8192 vs. 256 processors
Scaling type: weak

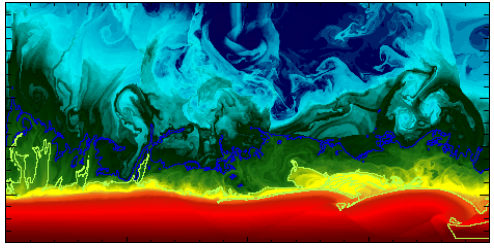


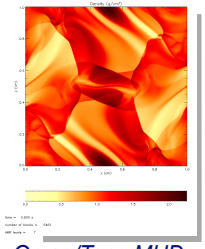
Magnetic Rayleigh-Taylor

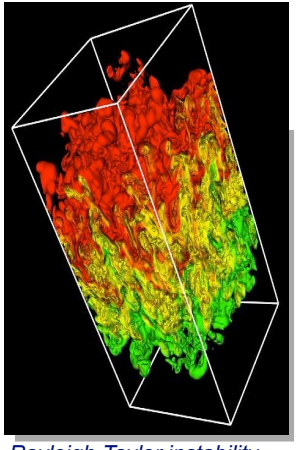

Nova outbursts on white dwarfs


Cellular detonation


Laser-driven shock instabilities

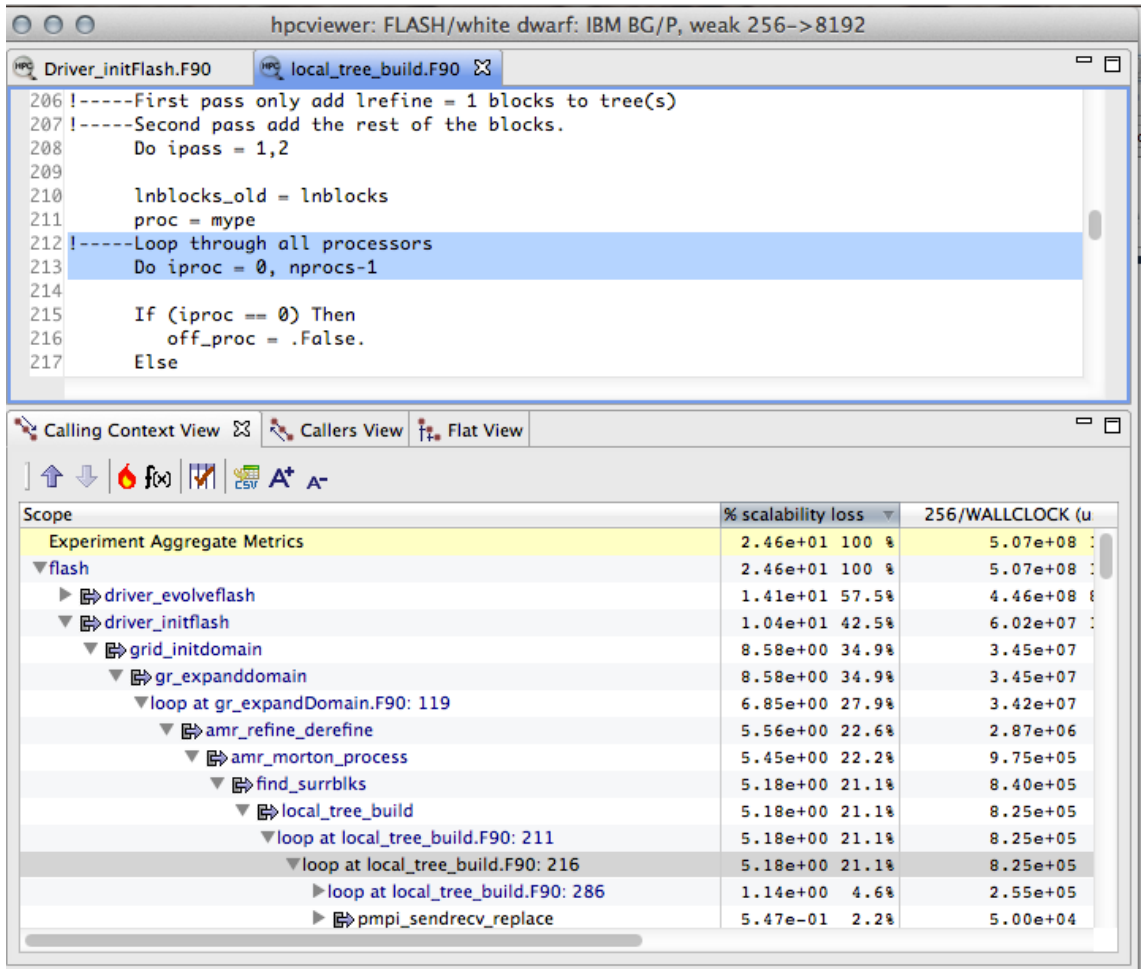

Helium burning on neutron stars


Orzag/Tang MHD vortex


Rayleigh-Taylor instability

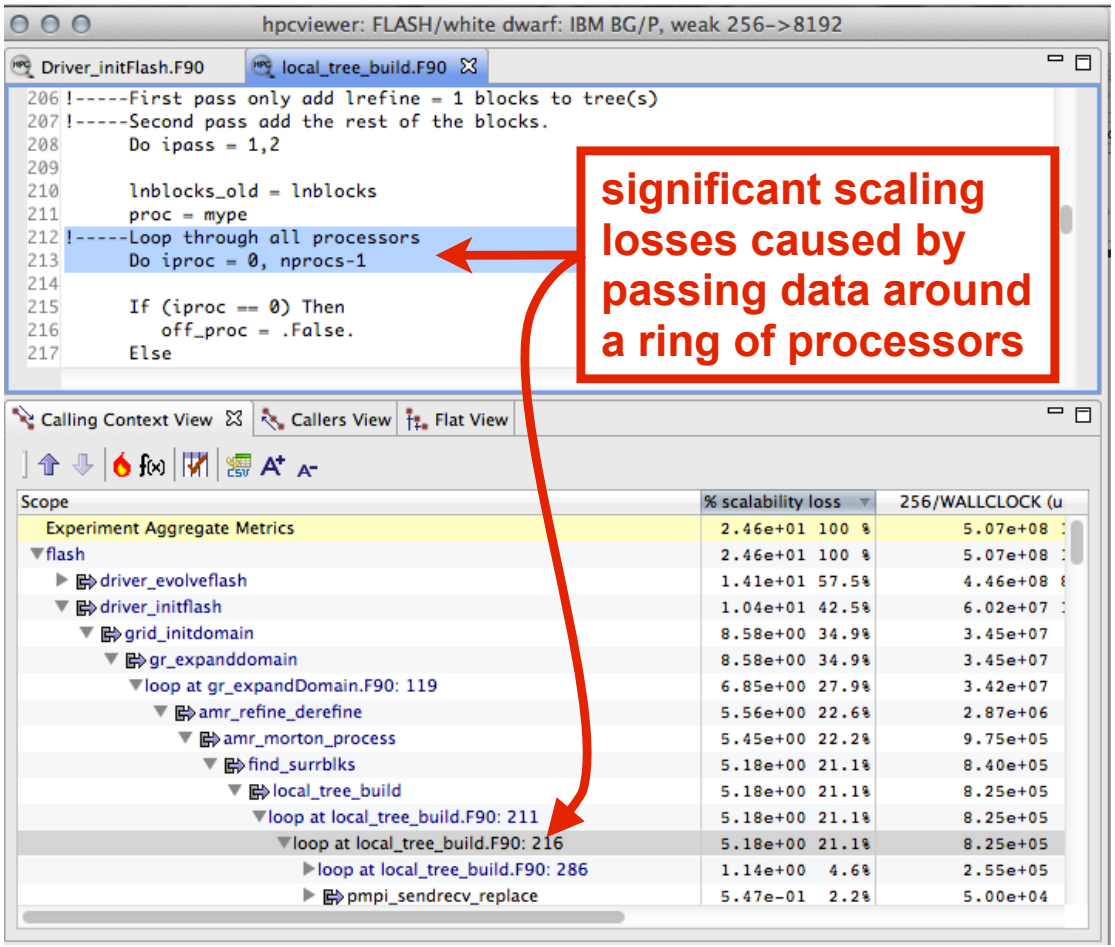
Figures courtesy of FLASH Team, University of Chicago

Scalability Analysis of Flash (Demo)

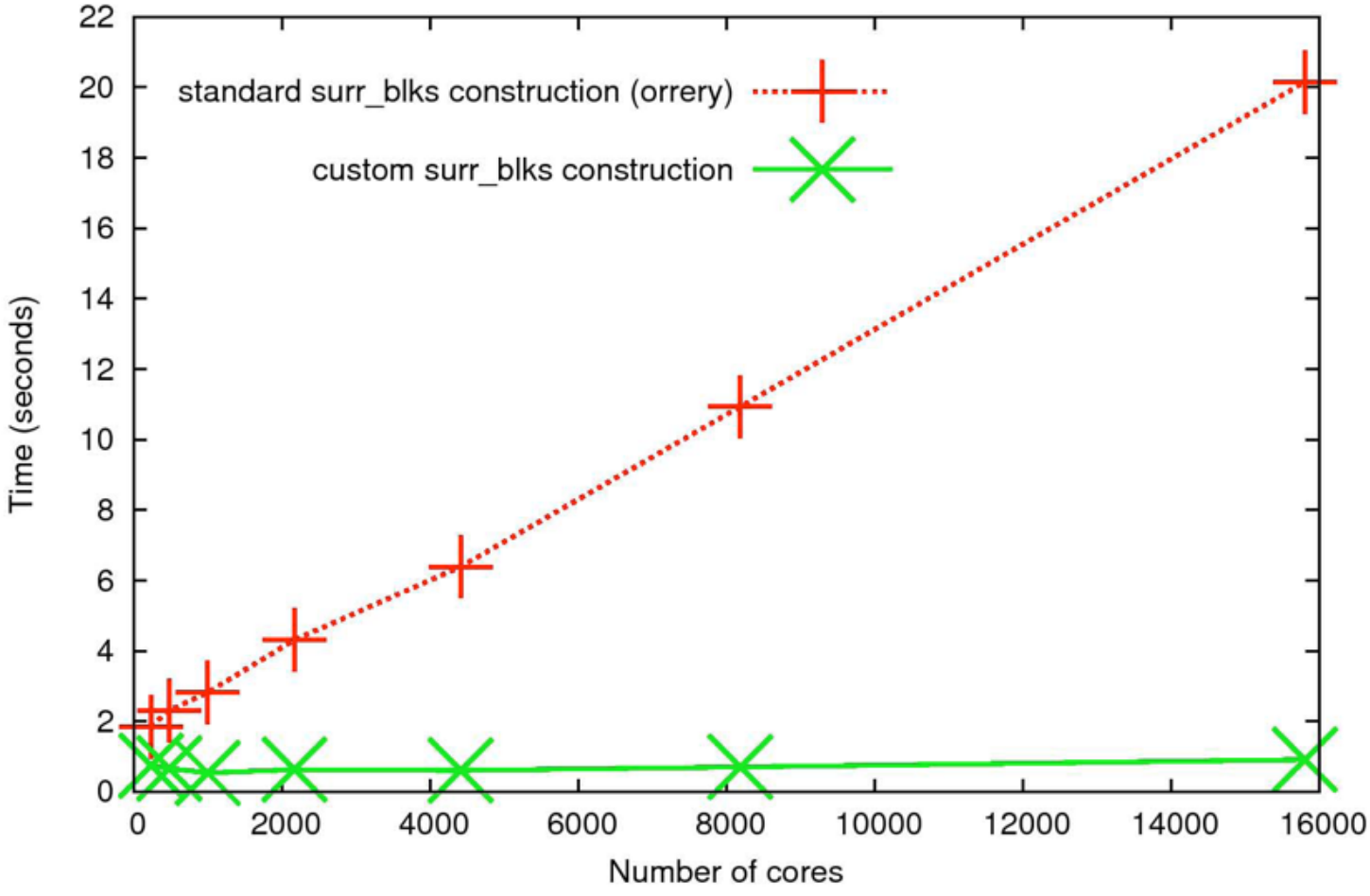


Scalability Analysis

- Difference call path profile from two executions
  - different number of nodes
  - different number of threads
- Pinpoint and quantify scalability bottlenecks within and across nodes



Improved Flash Scaling of AMR Setup



Graph courtesy of Anshu Dubey, U Chicago

Using Differential Performance Analysis

- The example shown was a hand-crafted database created using a single MPI rank from each of two executions at different scales
- You can do strong or weak scaling analysis on your own by
  - providing two measurement directories to hpcprof/hpcprof-mpi
  - writing an equation to compute the scaling loss from one to the other

    or a worker thread did the work