Algorithmic Choices in Dense Linear Algebra and their Effect on Energy Consumption

Piotr Luszczek

Hatem Ltaief
Power, Performance, Energy: the Tension

\[ P = V^a f^b \]

\[ E = \int P \, dt \]

\[ \text{perf} = \frac{N \times \log(N)}{T} \]

- TDP
- Power plant
- Cooling
- Battery capacity
- Time to solution

Performance

Energy
LAPACK

panel
pivot
tri-solve tri-solve tri-solve
update update update
Panel

PLASMA

panel pivot pivot
tri-solve tri-solve
update panel update
BSP (fork-join)

Vendor: MKL, ACML, ...

DAG
Data Layout for Matrix Elements

Column-major (LAPACK and derivatives)  

Tile (PLASMA)
Monitoring Power Consumption with PowerPack
BSP (fork-join) vs. DAG Parallelism

Step 1  →  Step 2  →  Step 3  →  Step 4  · · ·
Cholesky: CPU Power

AMD Opteron 265 1.8 GHz
Total sockets: 2
Cores per socket: 2
RAM: SDRAM DDR2: 600 MHz
RAM modules per socket: 6
Cholesky: Memory Power

LAPACK

PLASMA
LU: CPU Power
Similarity (Two-Sided) Reductions

LAPACK

PLASMA

PLASMA
Overlap of Stages: the Matrix View
Tridiagonal Reduction: CPU Power

LAPACK

PLASMA
Tridiagonal Reduction:
Memory Power

PLASMA

LAPACK
Bidiagonal Reduction: CPU Power

LAPACK

PLASMA
Bidiagonal Reduction: CPU Power

 PLASMA

 LAPACK
DAG of Tasks: All Stages Overlapped

Matrix Inversion
Power consumption over time

Matrix inverse
Runtime Scheduling with Energy as a Criterion

CPU Intensive

Memory Intensive

PLASMA

QUARK

DVFS