Hierarchical Computations on Manycore Architectures Powered by the PaRSEC Runtime System

HiCMA Powered by PaRSEC

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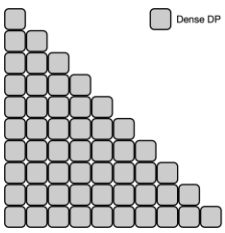
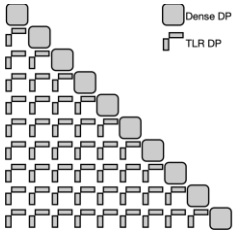
The Hierarchical Computations on Manycore Architectures (HiCMA) library, which is powered by the PaRSEC runtime system, extends dense linear algebra libraries toward hierarchical computations on distributed many-core, heterogeneous architectures. The core idea of HiCMA is to develop fast linear algebra computations on dense, low-rank, mixed-precision, and sparse data formats for scientific and AI applications, while satisfying specified numerical accuracy and leveraging massively parallel heterogeneous hardware.

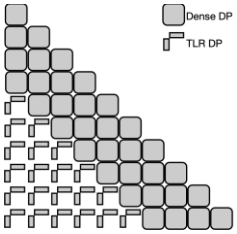
SUPPORTED MATRIX COMPUTATIONS



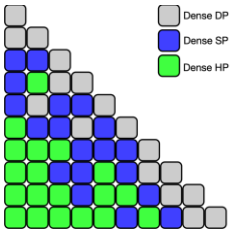
Dense; FP64



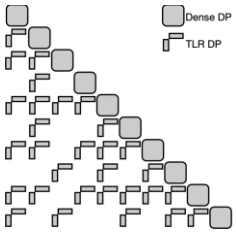
Diag Dense + TLR; FP64



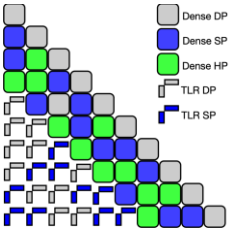
Band Dense + TLR; FP64



Dense; Adaptive Tile-Centric MP

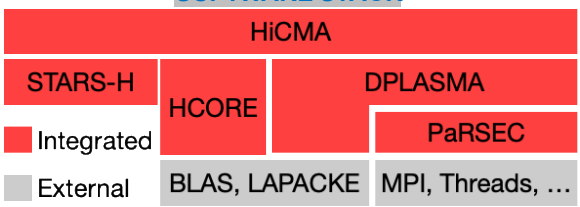


Diag Dense + TLR + Sparse; FP64

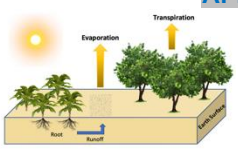


Band Dense + TLR; Adaptive Tile-Centric MP

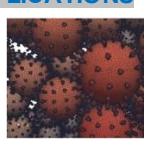
SOFTWARE STACK



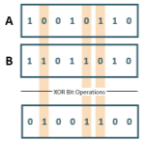
APPLICATIONS



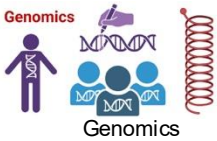
Geostatistical Modeling and Prediction



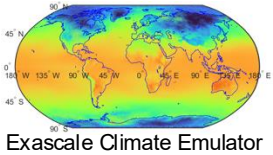
3D Unstructured Mesh Deformation



Hamming Distance



Genomics



Exascale Climate Emulator

CURRENT FEATURES

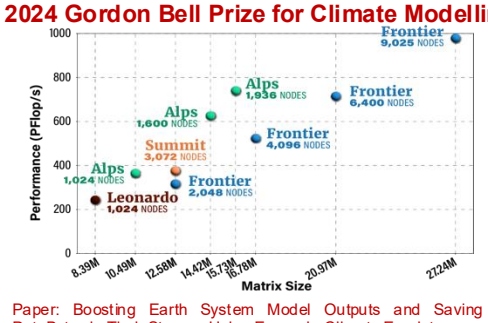
- **Matrix Computations:** Cholesky factorization, Matrix-matrix multiplication, Symmetric rank k update
- **Tile-Centric Mixed-Precision** (FP64, FP32, FP16, FP8, INT8, 1Bit), **Tile Low-Rank** (TLR) Approximation, and **Sparse** Computations
- **Memory Layout:** LAPACK and DPLASMA/tile
- **Hardware Supports:** CPUs and GPUs (Nvidia and AMD), Shared and distributed-memory environments

FUTURE DIRECTIONS

- Julia Integration
- LU and QR Factorizations
- Tile Low-Rank on GPUs
- Sparse Direct Solvers
- NVIDIA CUTLASS
- Precision Emulation

GITHUB REPO

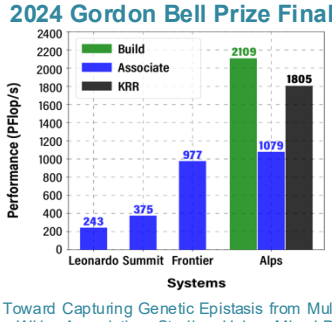
2024 Gordon Bell Prize for Climate Modeling



Paper: Boosting Earth System Model Outputs and Saving PetaBytes in Their Storage Using Exascale Climate Emulators

Stochastically capture spatio-temporal variability, accelerate computation, improve emulator accuracy, and yield insights on climate change and extremes.

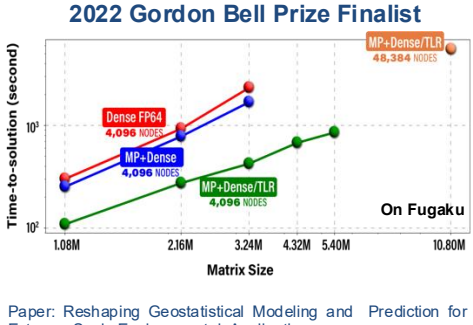
2024 Gordon Bell Prize Finalist



Paper: Toward Capturing Genetic Epistasis from Multivariate Genome-Wide Association Studies Using Mixed-Precision Kernel Ridge Regression

Enhance Kernel Ridge Regression (KRR) and achieve a performance improvement of five orders of magnitude over the state-of-the-art CPU-only REGENIE.

2022 Gordon Bell Prize Finalist



Paper: Reshaping Geostatistical Modeling and Prediction for Extreme-Scale Environmental Applications

Extend the capability of space-time geostatistical modeling using algebraic approximations and illustrate application-expected accuracy worthy of double precision from majority low-precision computations and low-rank matrix approximations.

A collaboration of

KAUST
THE UNIVERSITY OF TENNESSEE KNOXVILLE
Massachusetts Institute of Technology
SAINT LOUIS UNIVERSITY
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