Benchmark notes

- LAK is safe-Rust.
- All benchmarks are single-threaded on an Apple M4 with 16 GB unified memory.
- Comparisons use OpenBLAS armv8, BLIS, and Apple Accelerate where shown.
- BLIS is omitted from Level-1 and Level-2 because this backend is not optimized for those routines.
- Accelerate is omitted from Level-2 and Level-3 because it uses Apple's AMX which is cheating.
- OpenBLAS armv8 is included throughout; but its ARM64 kernels target Level-2 and Level-3 most directly.
- Level-1 and Level-2 report GB/s; Level-3 reports GFLOP/s.
- All matrices are square $n \times n$.

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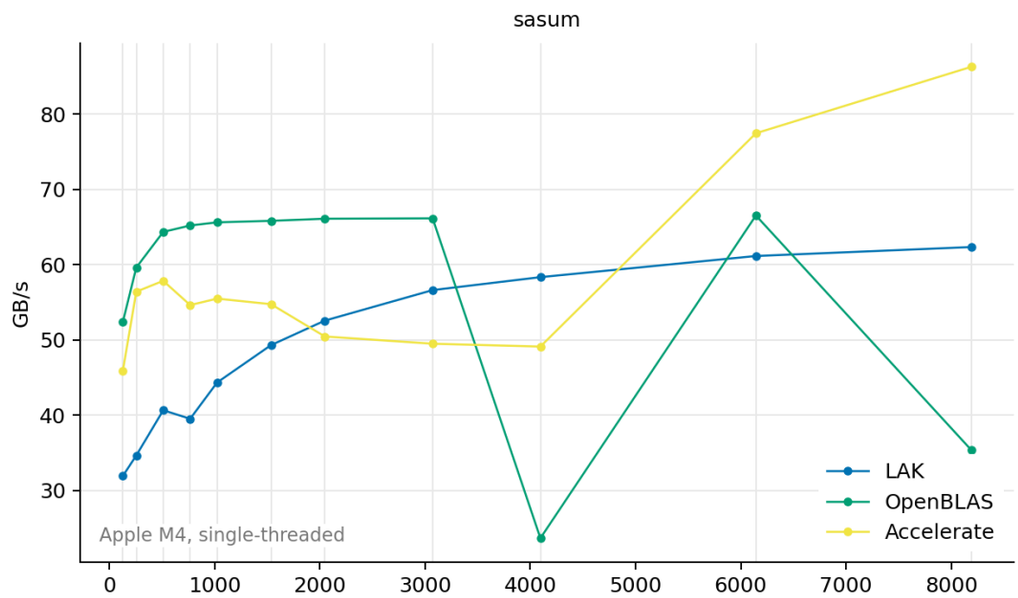
Level-1

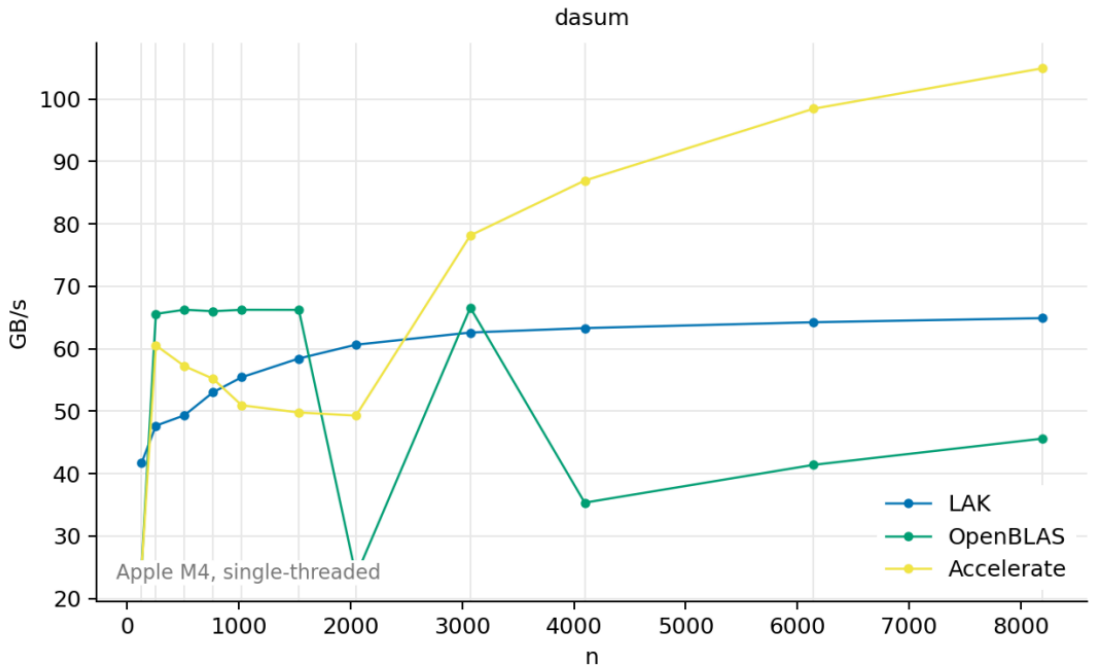
ASUM

$SASUM$: $s \leftarrow \sum_i |x_i|$



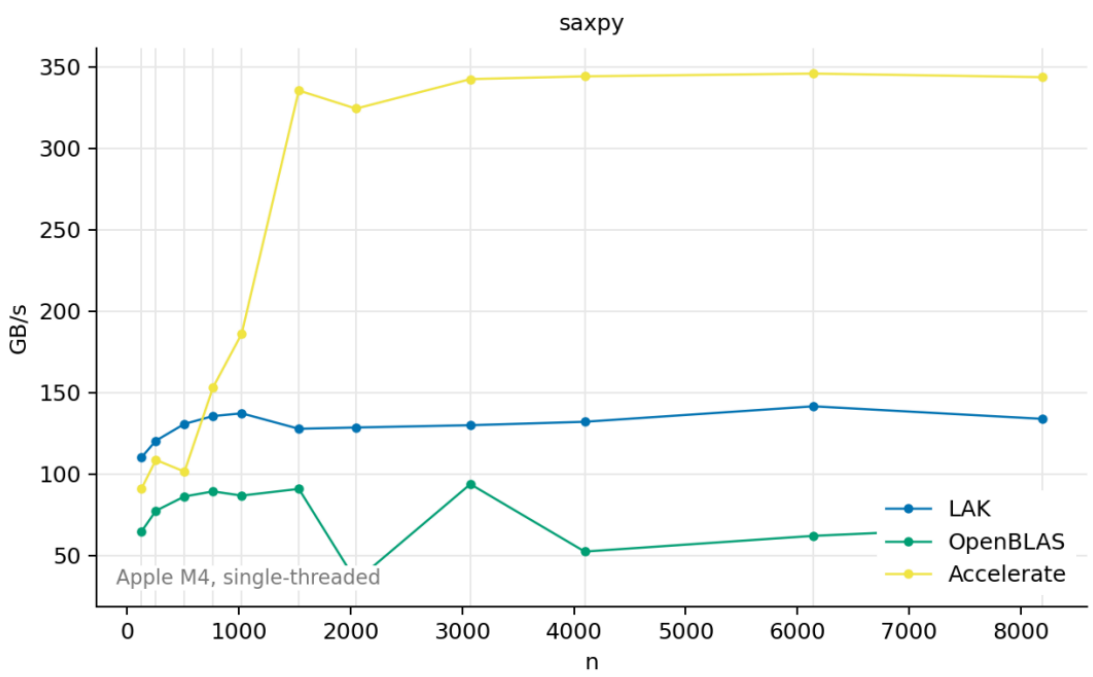
n

$DASUM$: $s \leftarrow \sum_i |x_i|$



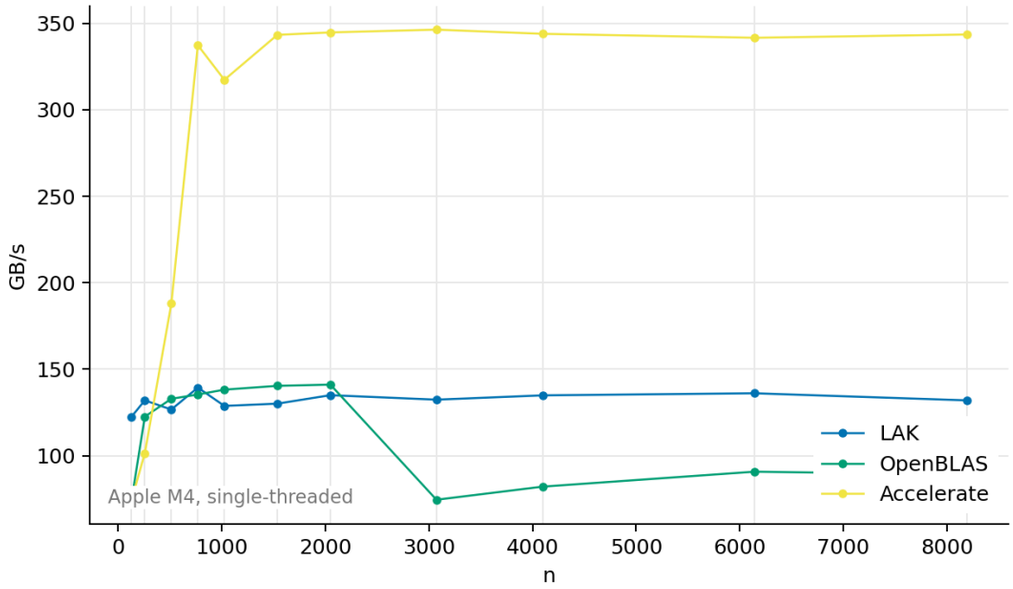
AXPY

$SAXPY$: $y \leftarrow \alpha x + y$



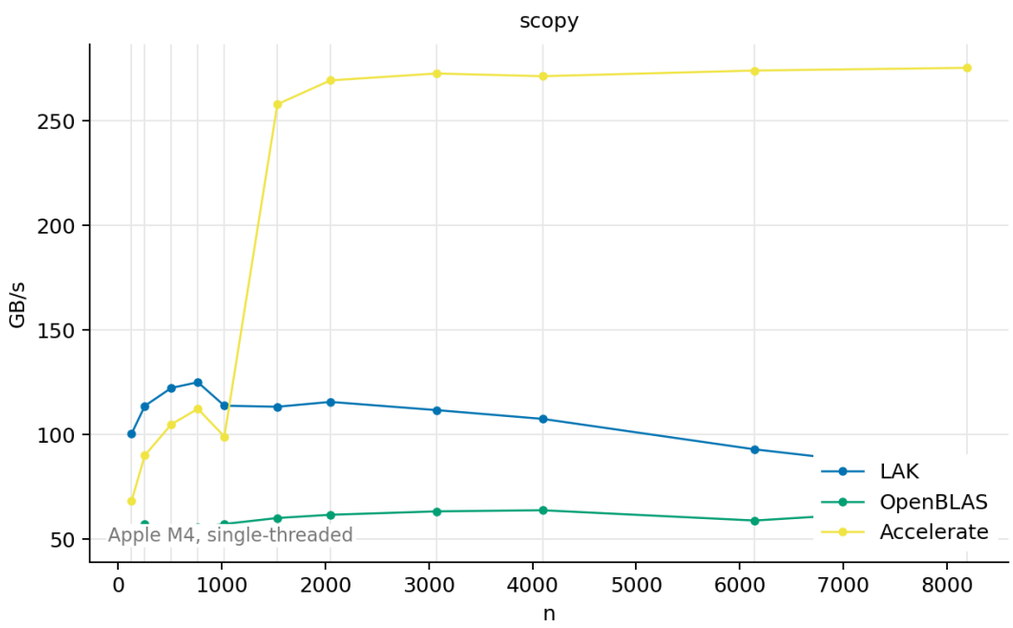
$DAXPY$: $y \leftarrow \alpha x + y$

daxpy

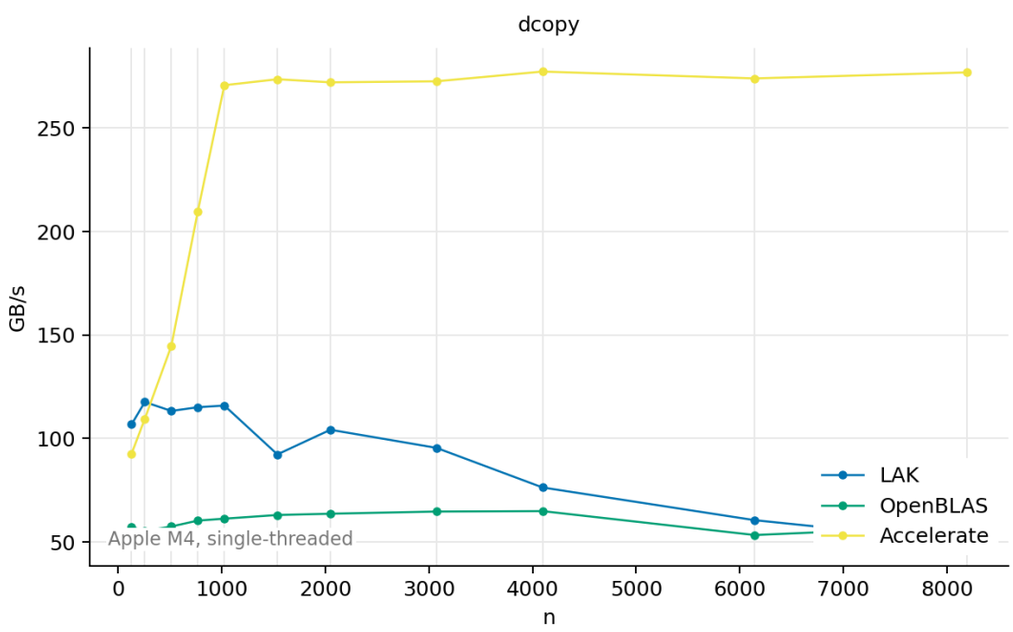


COPY

$SCOPY$: $y \leftarrow x$

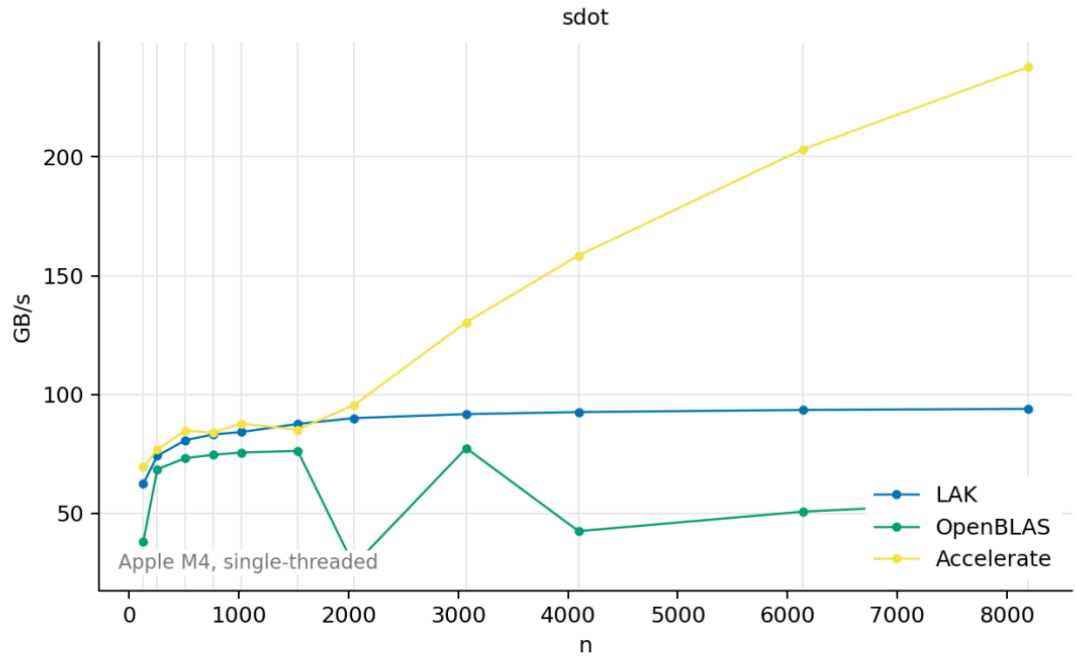


$DCOPY$: $y \leftarrow x$

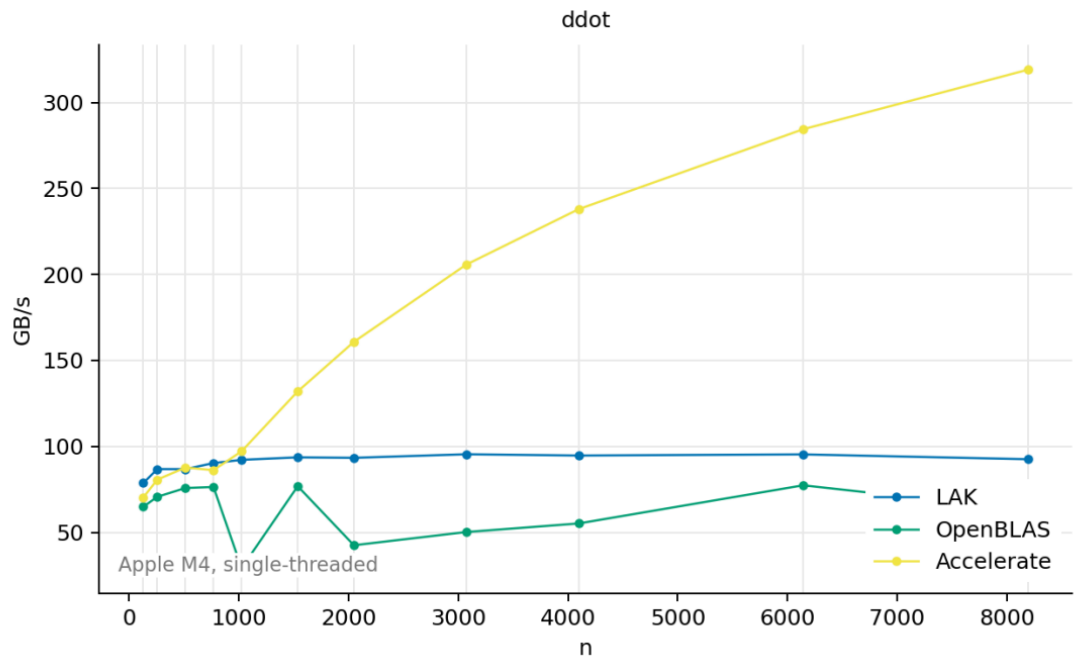


DOT

$SDOT$: $s \leftarrow x^T y$

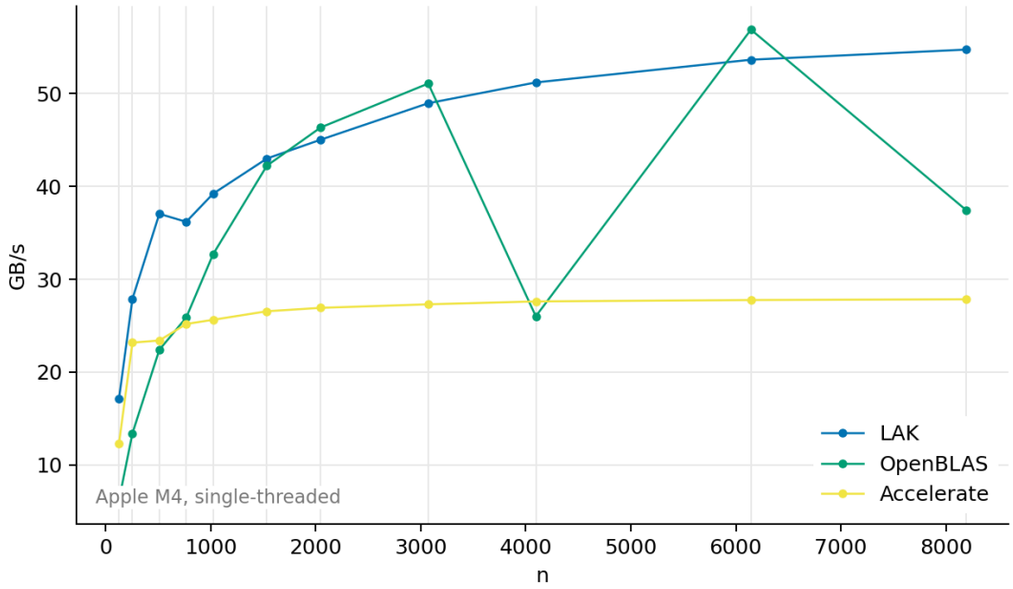


$DDOT$: $s \leftarrow x^T y$

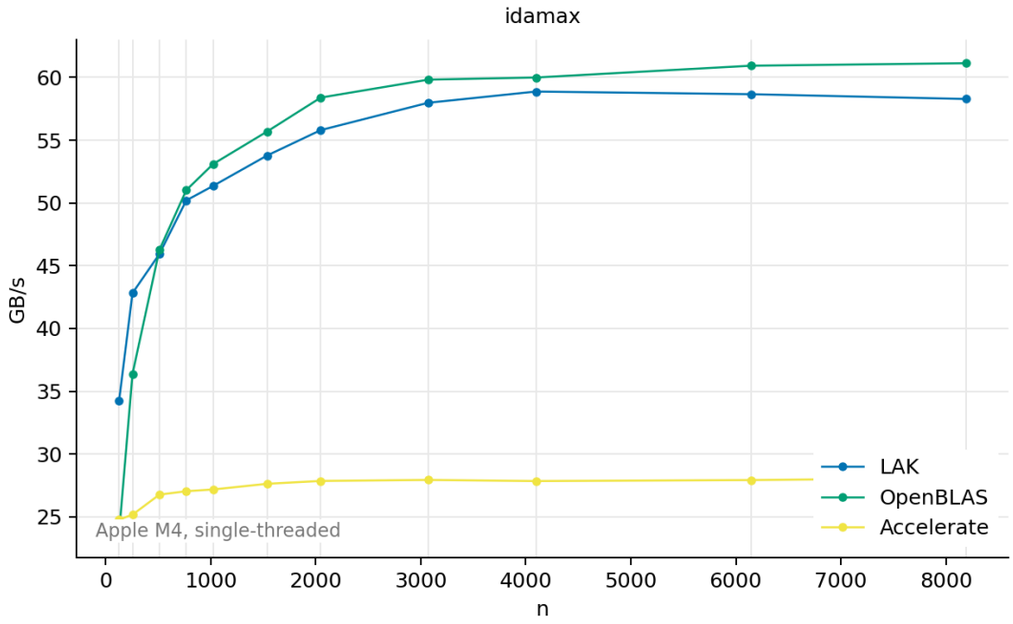


IAMAX

$ISAMAX$: $i \leftarrow \arg\max_j |x_j|$

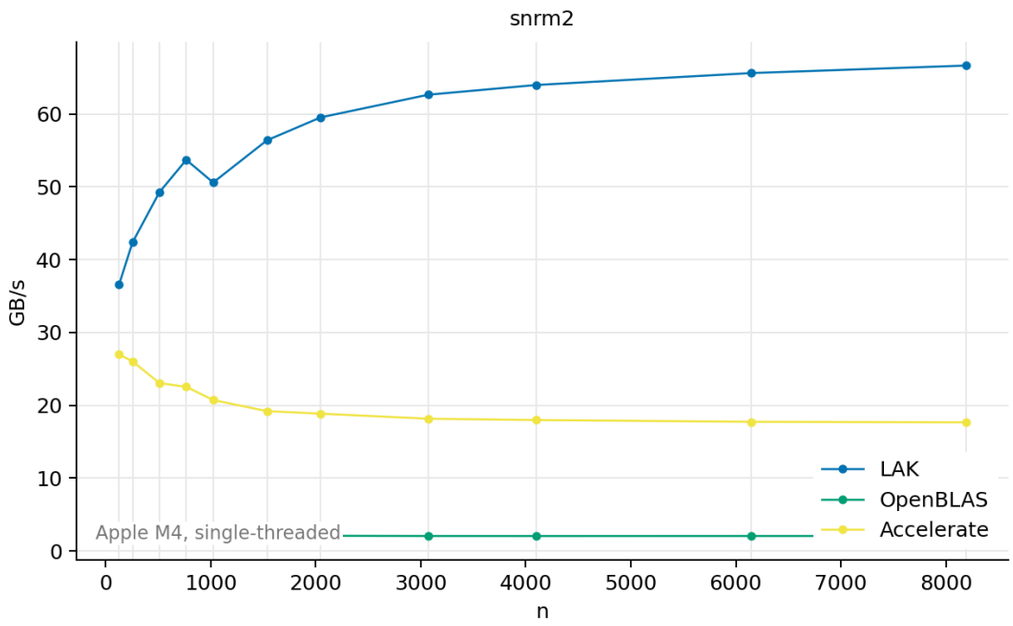


$IDAMAX$: $i \leftarrow \arg\max_j |x_j|$

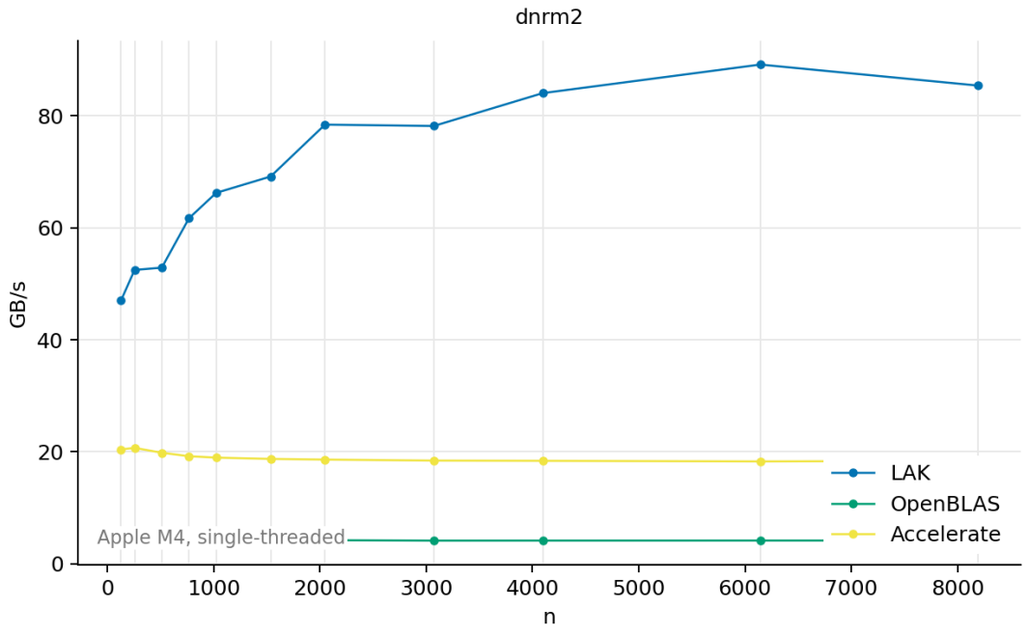


NRM2

$SNRM2$: $s \leftarrow \sqrt{x^T x}$

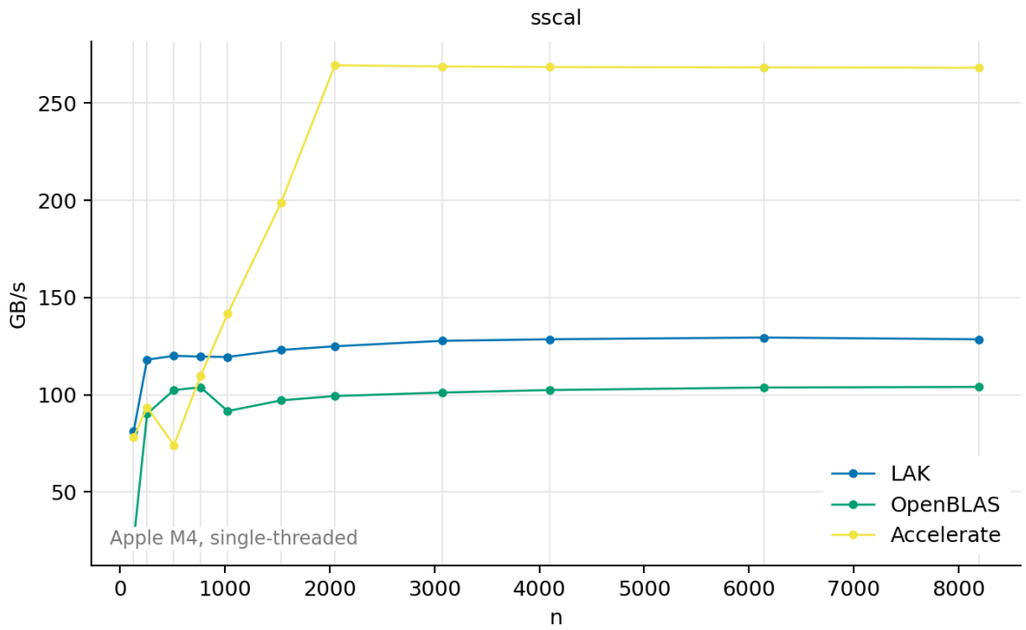


DNRM2: $s \leftarrow \sqrt{x^T x}$

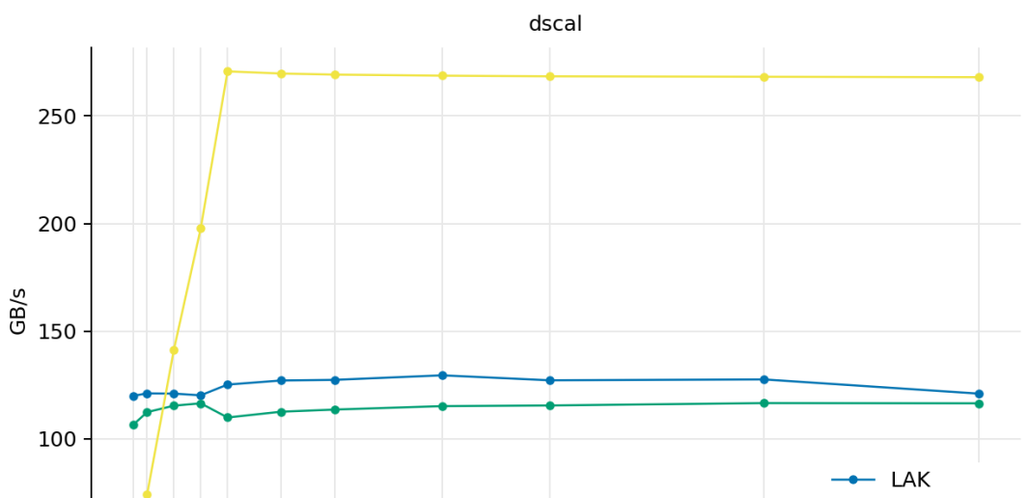


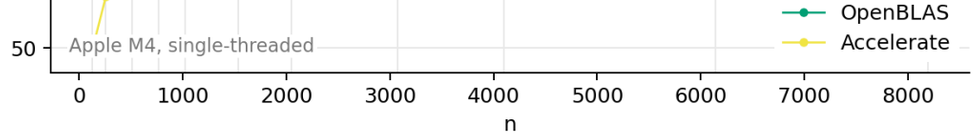
SCAL

SSCAL: $x \leftarrow \alpha x$



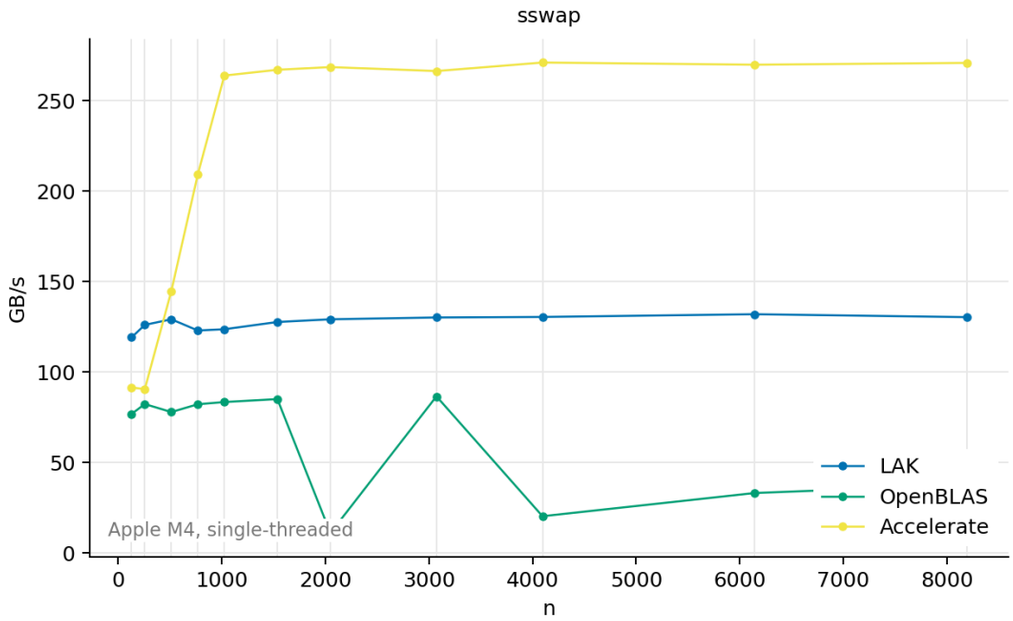
DSCAL: $x \leftarrow \alpha x$



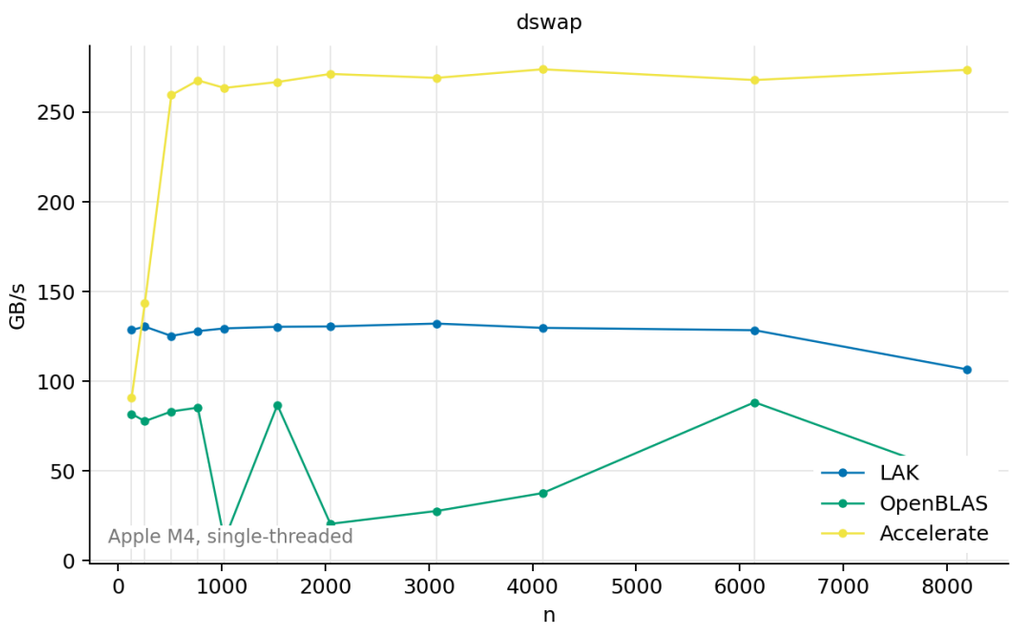


SWAP

$SSWAP$: $x \leftrightarrow y$



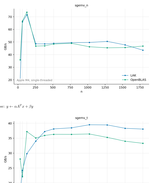
$DSWAP$: $x \leftrightarrow y$



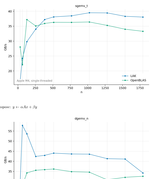
Level-2

GEMV

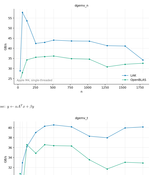
SGEMV, no transpose: $y \leftarrow \alpha Ax + \beta y$



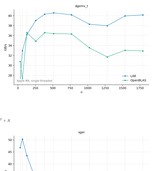
SGEMV, transpose: $y \leftarrow \alpha A^T x + \beta y$



DGEMV, no transpose: $y \leftarrow \alpha Ax + \beta y$

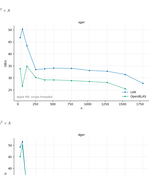


DGEMV, transpose: $y \leftarrow \alpha A^T x + \beta y$

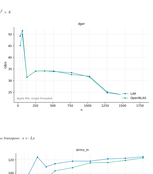


GER

SGER: $A \leftarrow \alpha xy^T + A$

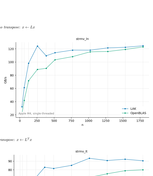


DGER: $A \leftarrow \alpha xy^T + A$

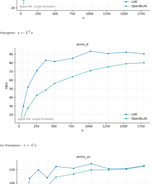


TRMV

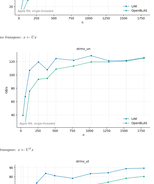
STRMV, lower no transpose: $x \leftarrow Lx$



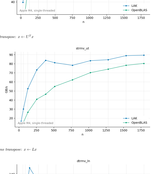
STRMV, lower transpose: $x \leftarrow L^T x$



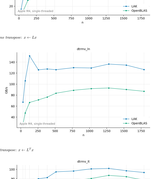
STRMV, upper no transpose: $x \leftarrow Ux$



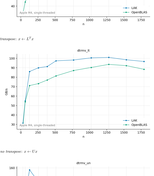
STRMV, upper transpose: $x \leftarrow U^T x$



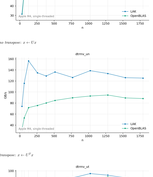
DTRMV, lower no transpose: $x \leftarrow Lx$



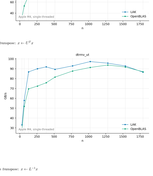
DTRMV, lower transpose: $x \leftarrow L^T x$



DTRMV, upper no transpose: $x \leftarrow Ux$

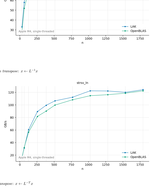


DTRMV, upper transpose: $x \leftarrow U^T x$

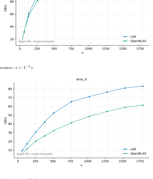


TRSV

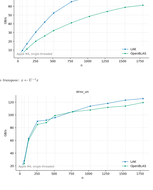
STRSV, lower no transpose: $x \leftarrow L^{-1}x$



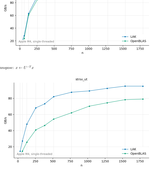
STRSV, lower transpose: $x \leftarrow L^{-T}x$



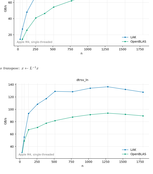
STRSV, upper no transpose: $x \leftarrow U^{-1}x$



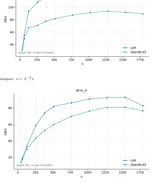
STRSV, upper transpose: $x \leftarrow U^{-T}x$



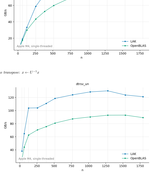
DTRSV, lower no transpose: $x \leftarrow L^{-1}x$



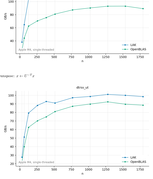
DTRSV, lower transpose: $x \leftarrow L^{-T}x$



DTRSV, upper no transpose: $x \leftarrow U^{-1}x$



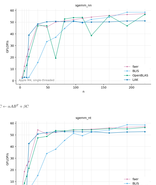
DTRSV, upper transpose: $x \leftarrow U^{-T}x$



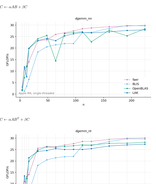
Level-3

GEMM, short

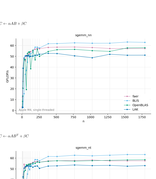
SGEMM, NN: C := αAB + βC



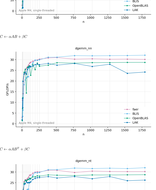
SGEMM, NT: C := αAB^T + βC



DGEMM, NN: C := αAB + βC

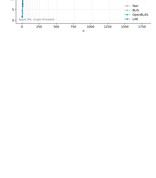


DGEMM, NT: C := αAB^T + βC



GEMM, tall

SGEMM, NN: C := αAB + βC



SGEMM, NT: C := αAB^T + βC

DGEMM, NN: C := αAB + βC

DGEMM, NT: C := αAB^T + βC