Productivity meets Performance Julia on A64FX

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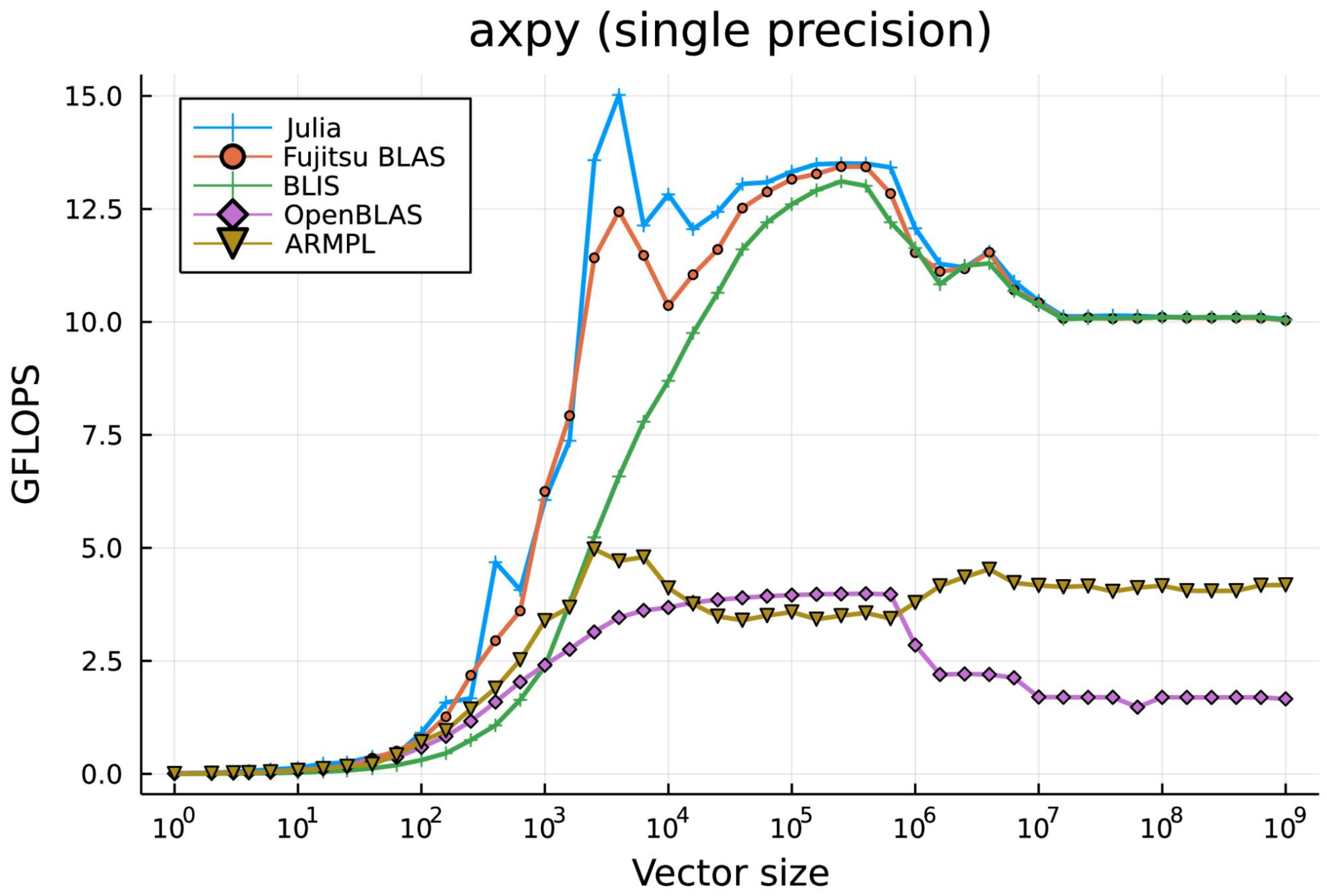
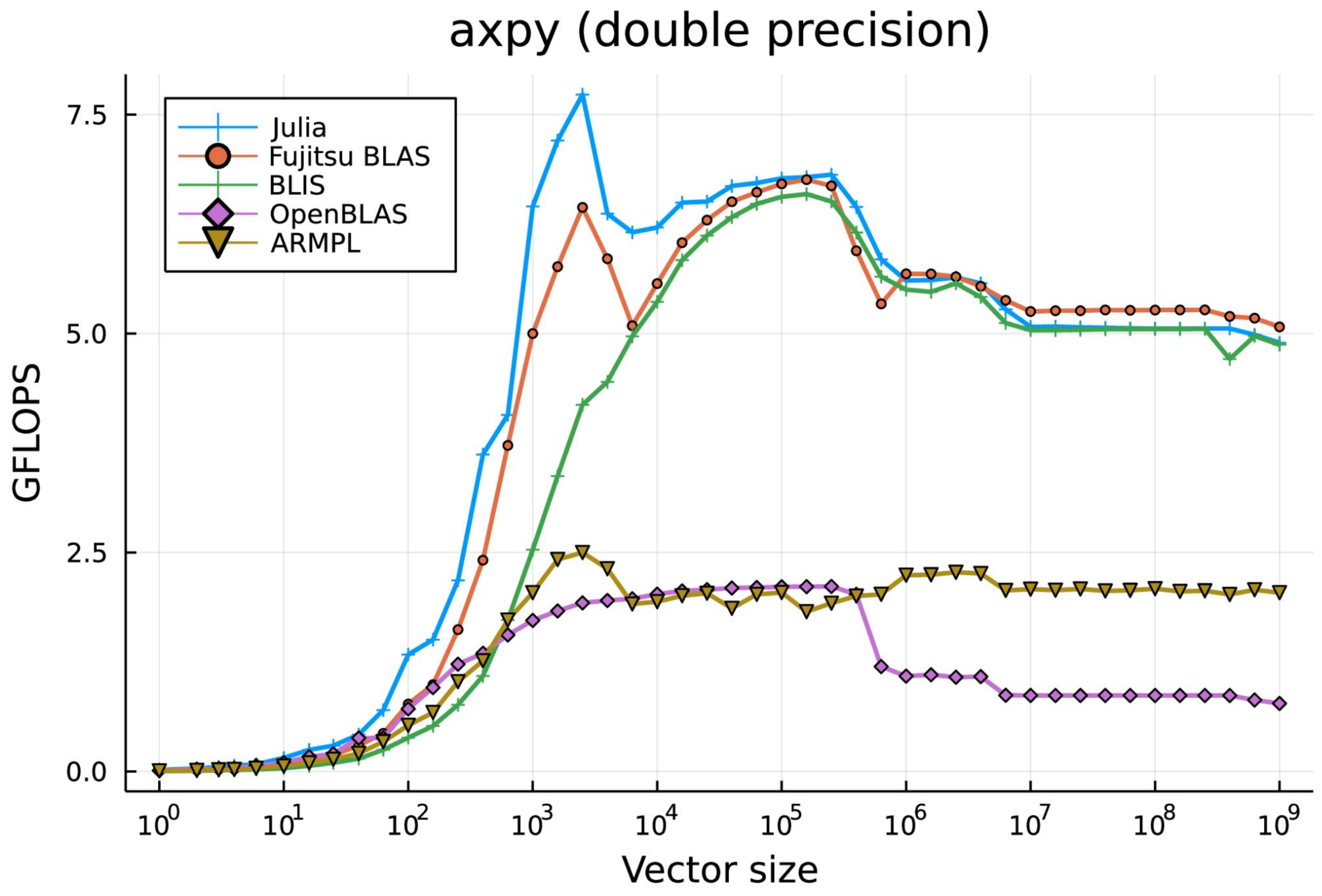
Level 1 BLAS showdown

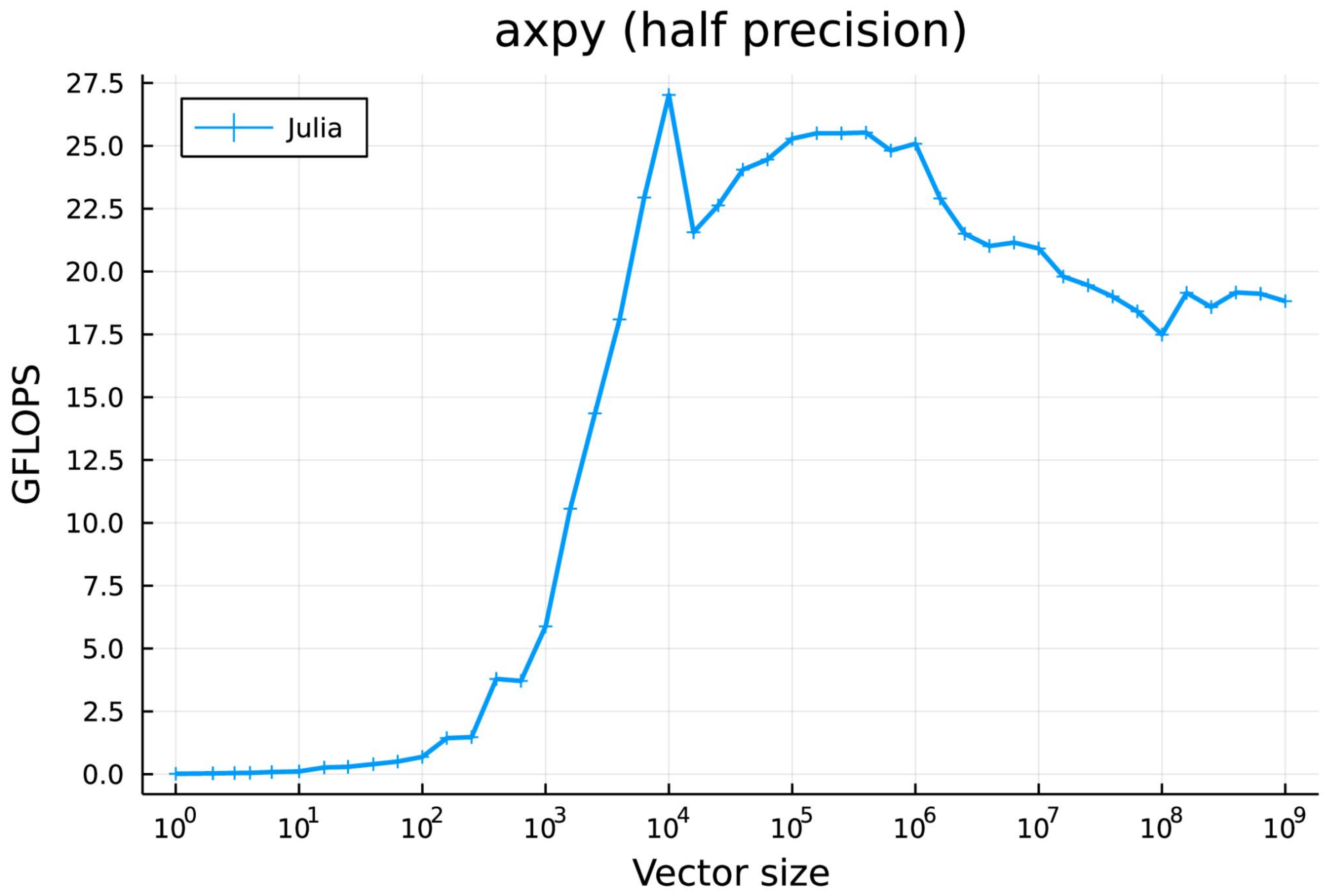
```
function axpy!(a, x, y)
    @simd for i in eachindex(x, y)
        @inbounds y[i] = muladd(a, x[i], y[i])
   end
   return y
end
```

vs

```
LinearAlgebra.BLAS.axpy!(a, x, y)
```

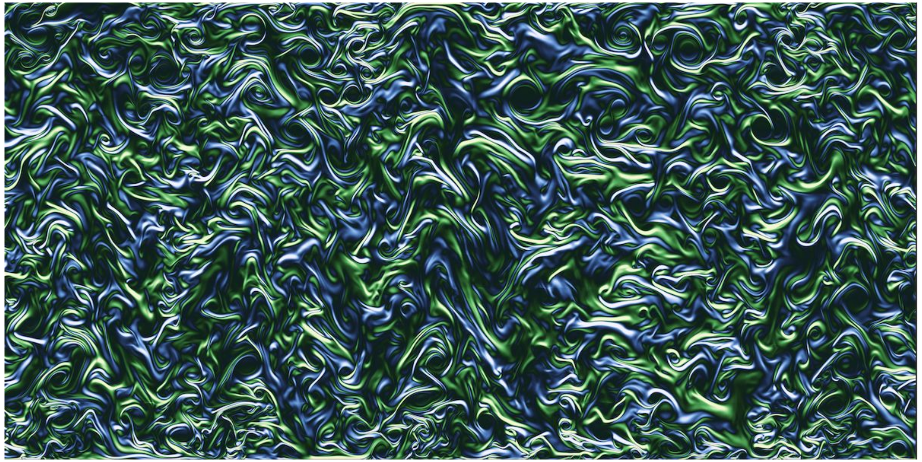

axpy (single precision)
Julia
Fujitsu BLAS
BLIS
OpenBLAS
ARMPL
GFLOPS
15.0
12.5
10.0
7.5
5.0
2.5
0.0
10^0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^9
Vector size


axpy (double precision)
Julia
Fujitsu BLAS
BLIS
OpenBLAS
ARMPL
7.5
5.0
2.5
0.0
GFLOPS
10^0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^9
Vector size

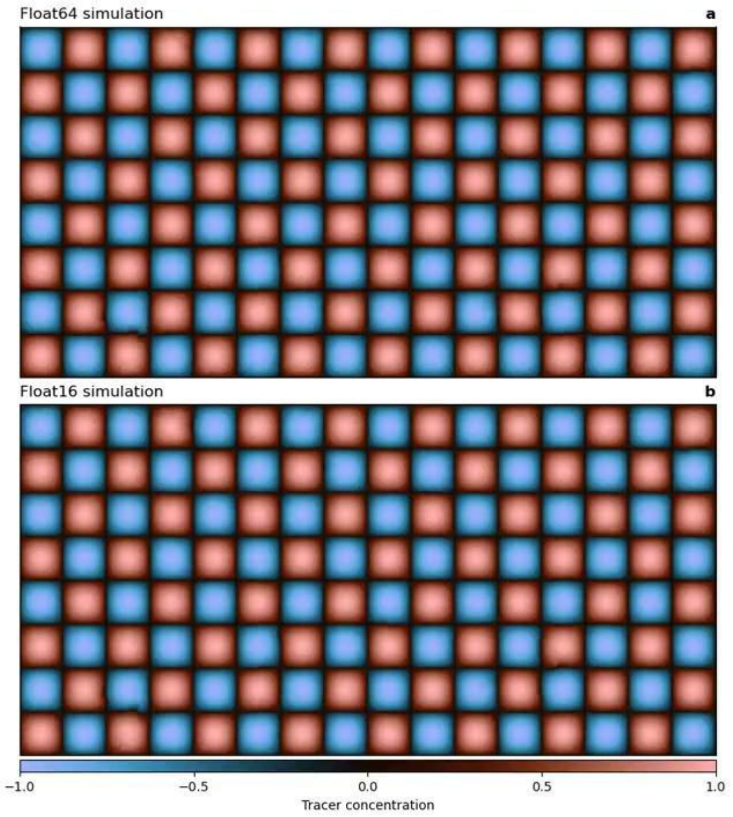

axpy (half precision)
Julia
GFLOPS
Vector size
27.5
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
10^0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^9

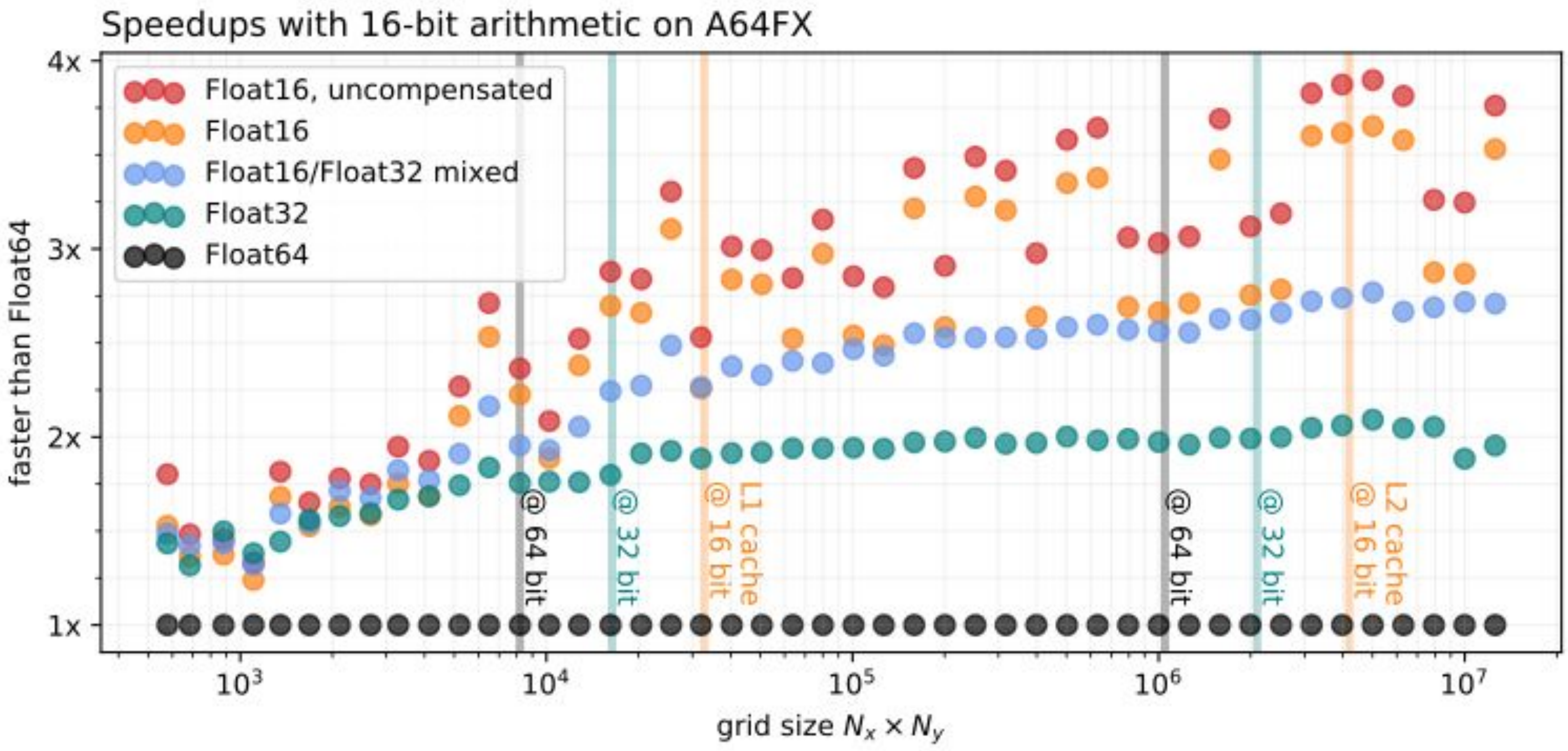
ShallowWaters.jl

- Open-Source CFD code written in Julia
- Type-agnostic/Type-flexible
  - Compensated summation for low-precision
- ~4x speedup with `Float16` and 2x speedup with `Float32` over `Float64`
- Qualitative results equivalent between `Float64` and `Float16`



ShallowWaters.jl — Fidelity comparison





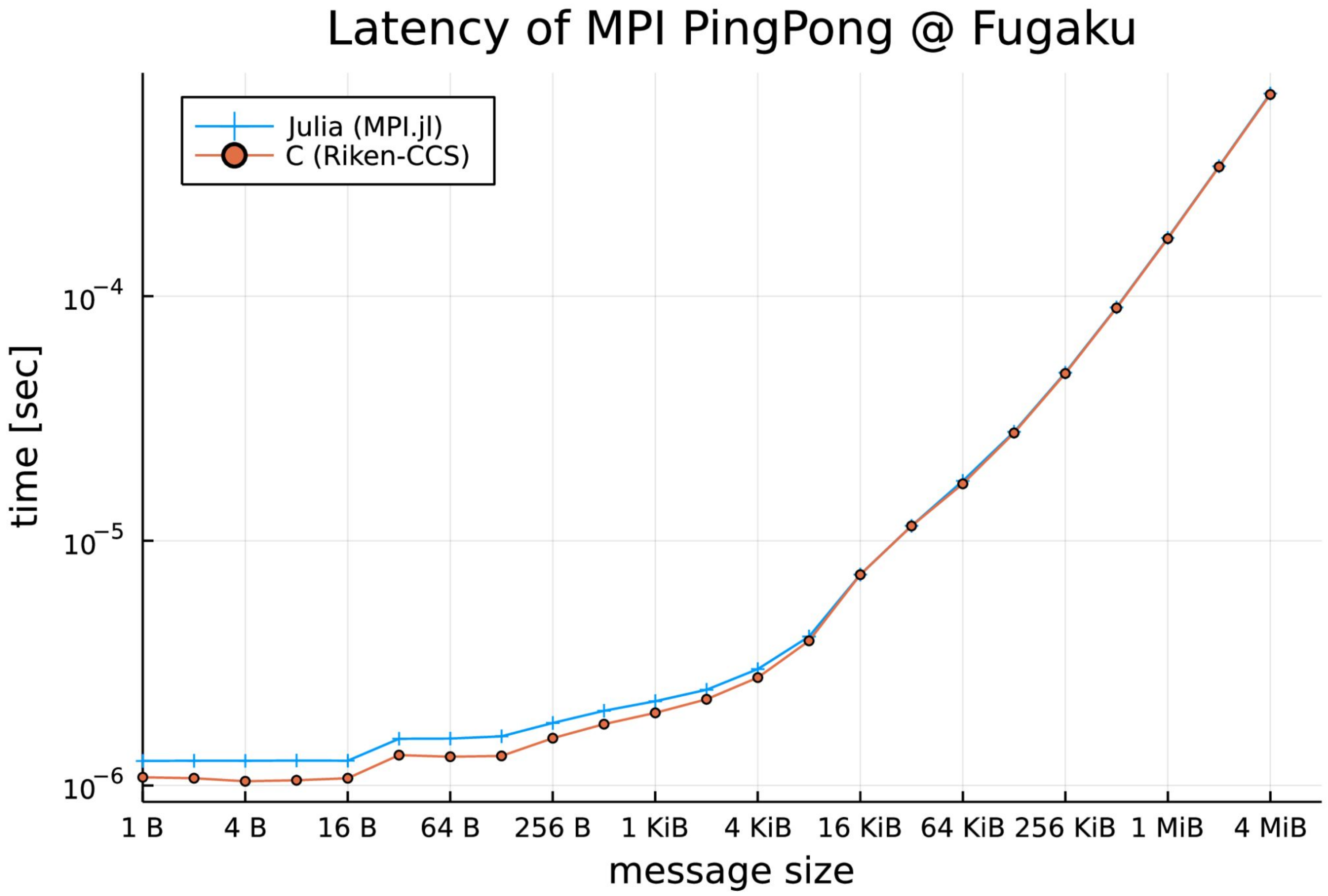
Reproduced from https://doi.org/10.1029/2021MS002684

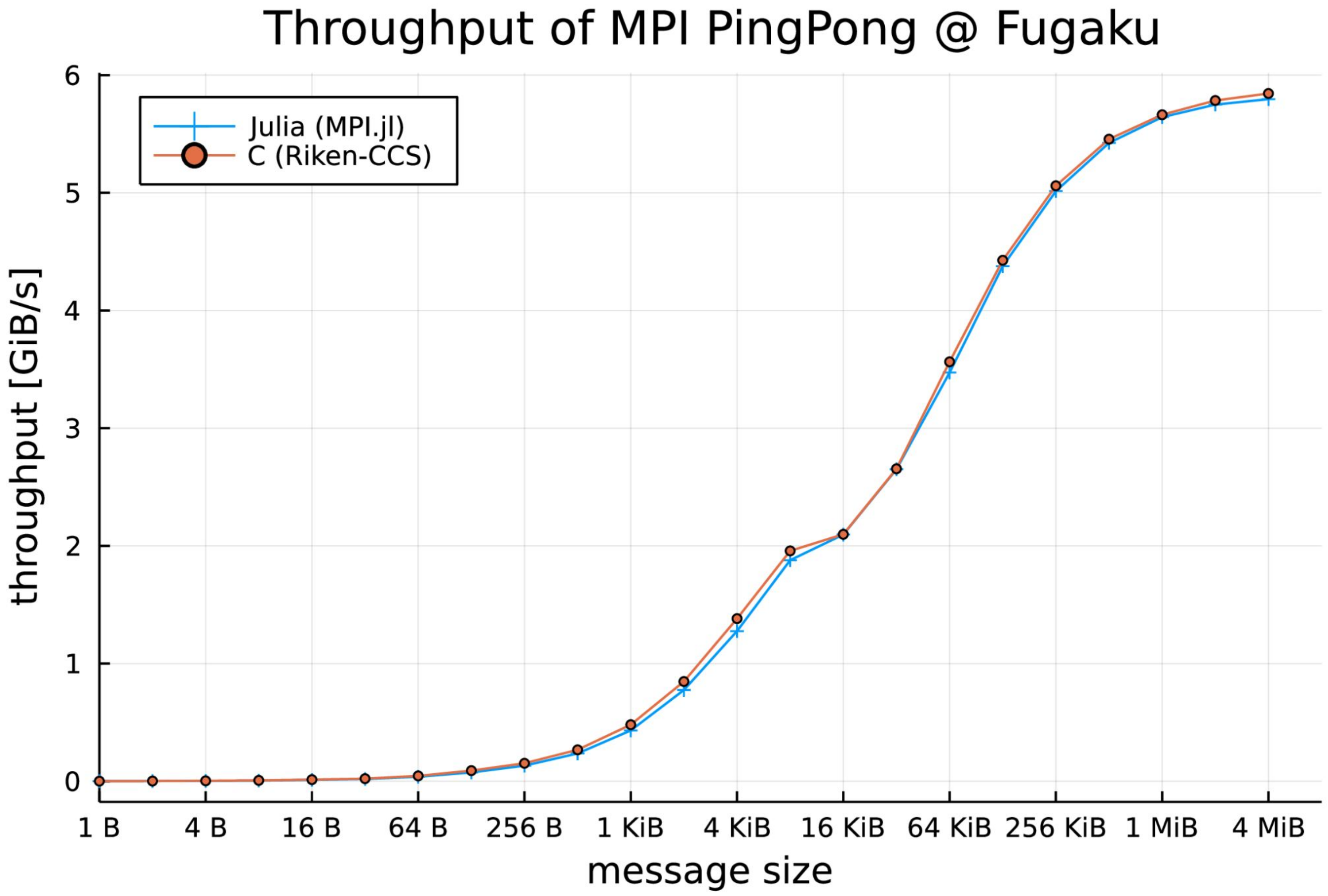
MPI.jl

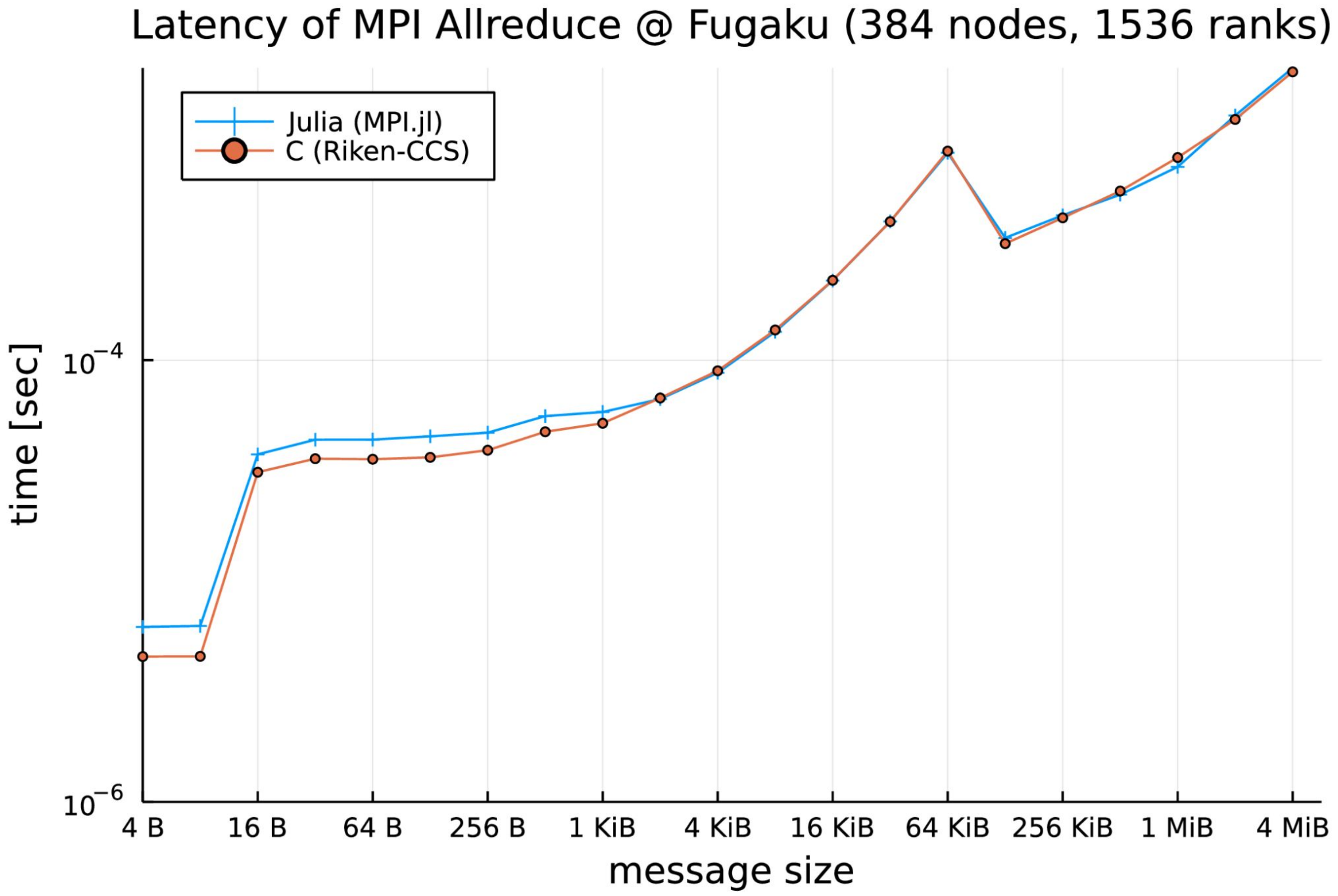
- Low-level access to MPI
- High-level convenience wrappers
- Deals with MPI ABI

One of the oldest Julia packages (2012)

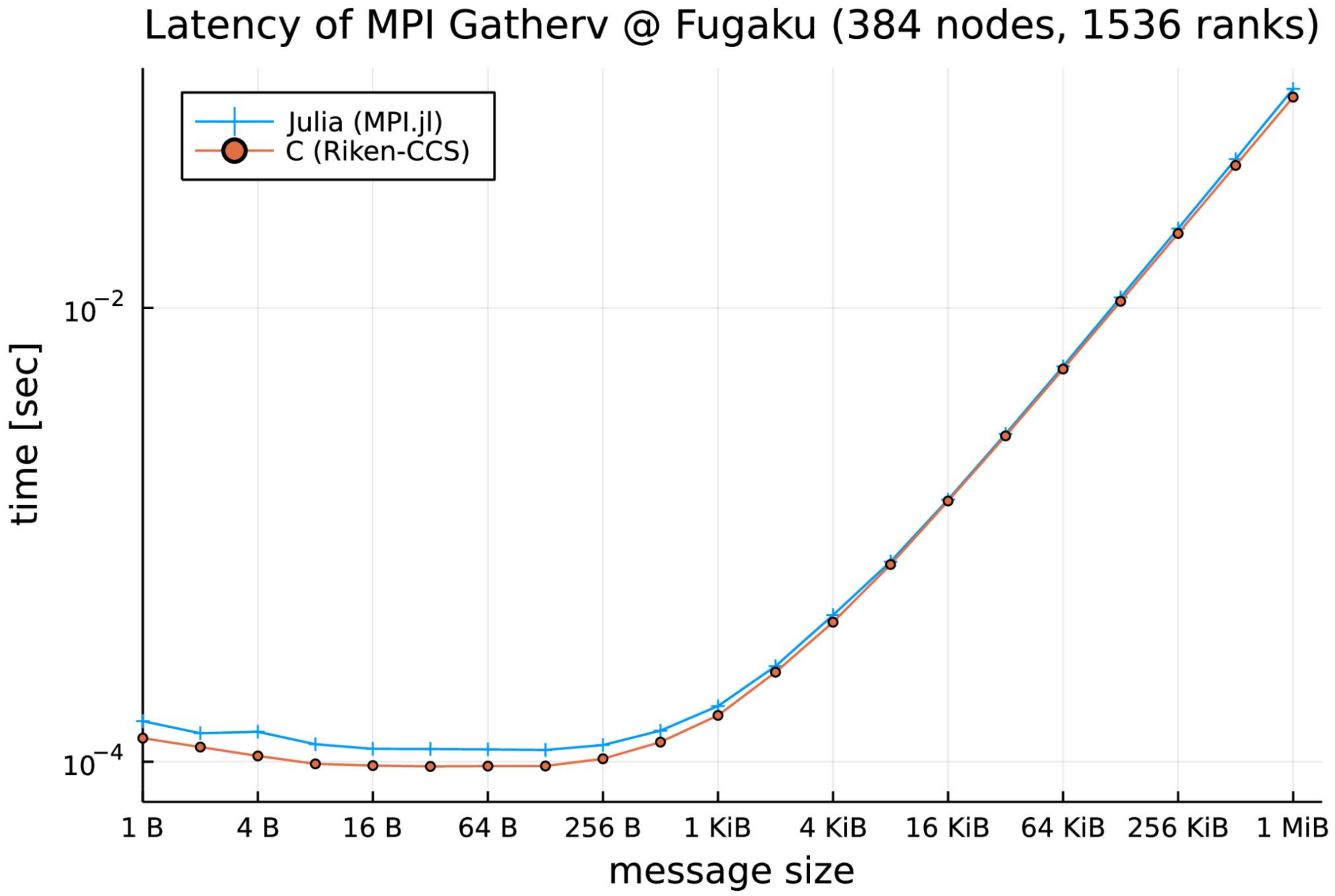
```julia
function pingpong(T::Type, bufsize::Int,
                          iters::Int, comm::MPI.Comm)
    rank = MPI.Comm_rank(comm)
    buffer = zeros(T, bufsize)
    tag = 0
    MPI.Barrier(comm)
    tic = MPI.Wtime()
    for i in 1:iters
        if iszero(rank)
            MPI.Send(buffer, comm; dest=1, tag)
            MPI.Recv!(buffer, comm; source=1, tag)
        elseif isone(rank)
            MPI.Recv!(buffer, comm; source=0, tag)
            MPI.Send(buffer, comm; dest=0, tag)
        end
    end
    toc = MPI.Wtime()
    return (toc - tic) / iters
end
```


Latency of MPI PingPong @ Fugaku
Julia (MPI.jl)
C (Riken-CCS)
time [sec]
10^{-4}
10^{-5}
10^{-6}
1 B
4 B
16 B
64 B
256 B
1 KiB
4 KiB
16 KiB
64 KiB
256 KiB
1 MiB
4 MiB
message size

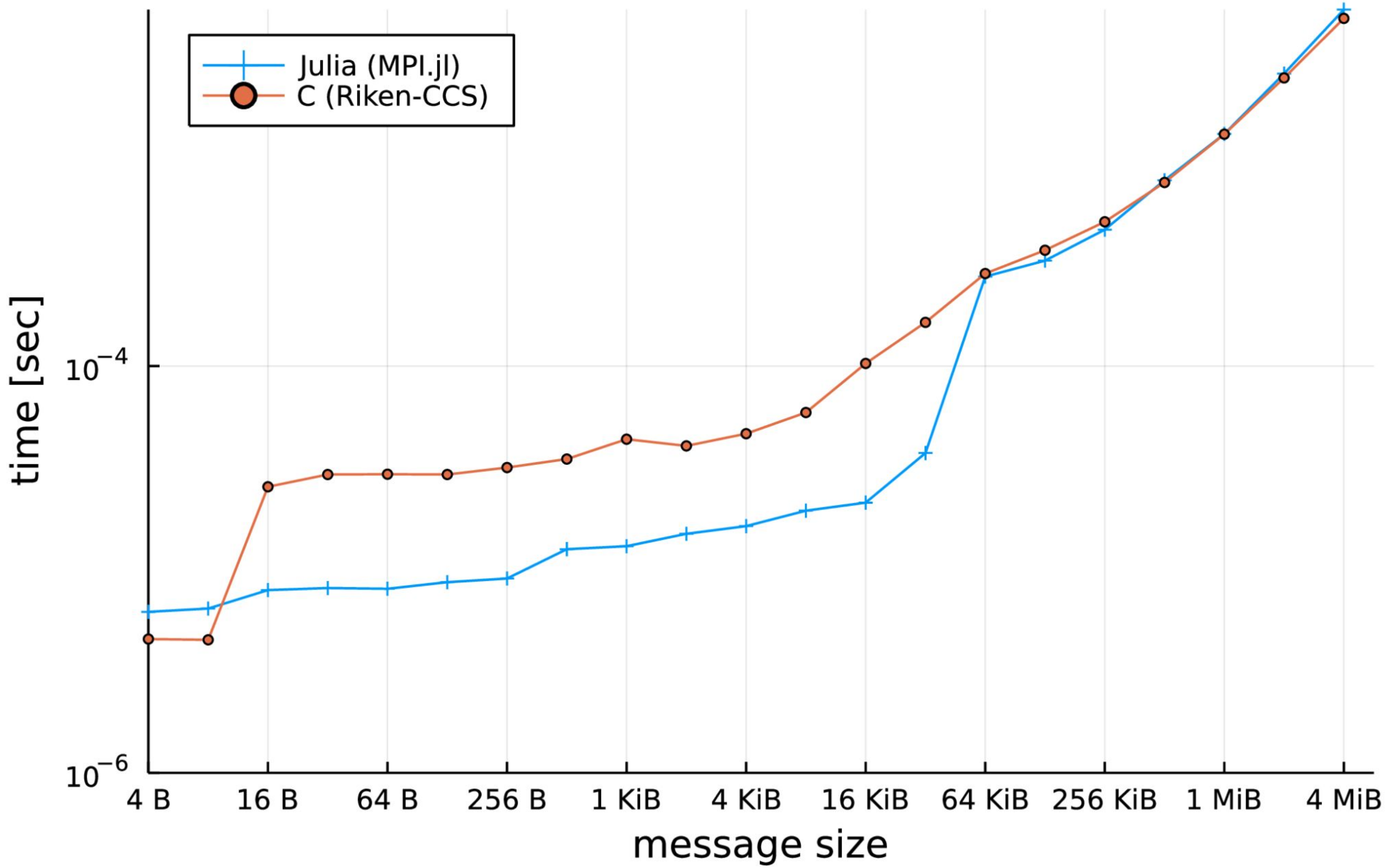

Throughput of MPI PingPong @ Fugaku
Julia (MPI.jl)
C (Riken-CCS)
throughput [GiB/s]
message size
0
1
2
3
4
5
6
1 B
4 B
16 B
64 B
256 B
1 KiB
4 KiB
16 KiB
64 KiB
256 KiB
1 MiB
4 MiB



Latency of MPI Allreduce @ Fugaku (384 nodes, 1536 ranks)
Julia (MPI.jl)
C (Riken-CCS)
time [sec]
10^{-4}
10^{-6}
4 B
16 B
64 B
256 B
1 KiB
4 KiB
16 KiB
64 KiB
256 KiB
1 MiB
4 MiB
message size


Latency of MPI Gatherv @ Fugaku (384 nodes, 1536 ranks)
Julia (MPI.jl)
C (Riken-CCS)
time [sec]
10^{-2}
10^{-4}
1 B
4 B
16 B
64 B
256 B
1 KiB
4 KiB
16 KiB
64 KiB
256 KiB
1 MiB
message size

Latency of MPI Reduce @ Fugaku (384 nodes, 1536 ranks)


Julia (MPI.jl)
C (Riken-CCS)
time [sec]
10^{-4}
10^{-6}
4 B
16 B
64 B
256 B
1 KiB
4 KiB
16 KiB
64 KiB
256 KiB
1 MiB
4 MiB
message size