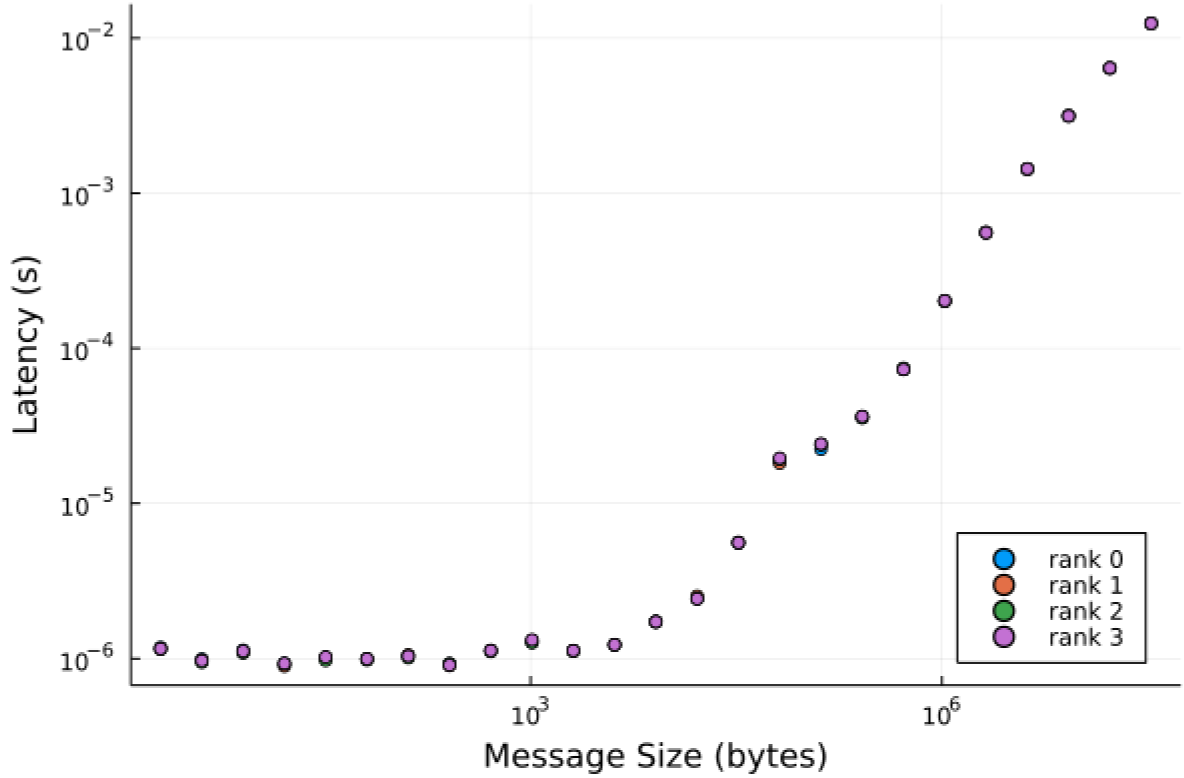
6.338 HW 4 — Jeremiah DeGreeff — Spring 2022

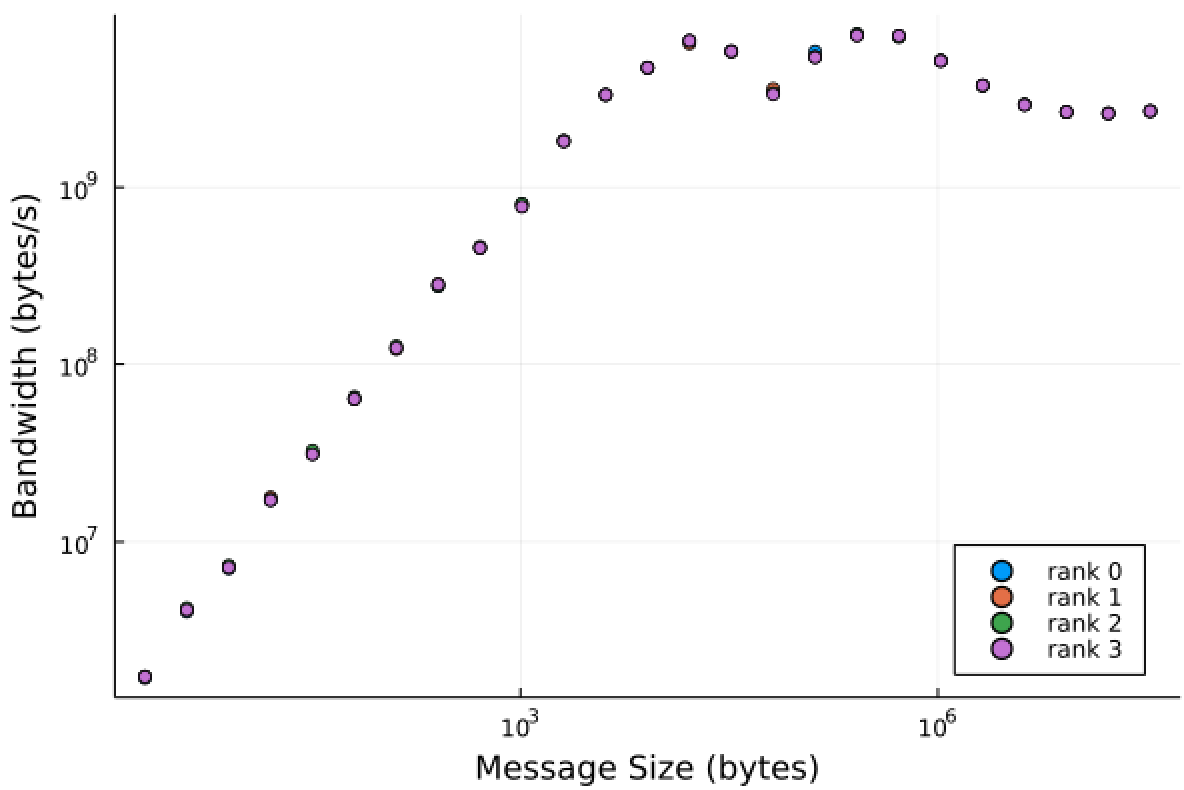
Part 1: Serial Bandwidth

```julia
using MPI
using Plots
using Statistics

# Setup

MPI.Init()
comm = MPI.COMM_WORLD
rank = MPI.Comm_rank(comm)
nproc = MPI.Comm_size(comm)
rank_s = mod(rank + 1, nproc)
rank_r = mod(rank - 1, nproc)

MPI.Barrier(comm)
rank == 0 && println("FINISHED INITIALIZATION")

# Data Collection for Serial Bandwidth

const N = 25
const N_SAMPLES = 1000
const sizes = [2^n for n ∈ 1:N]

const send = (s -> rand(Int8, s)).(sizes)
recv = similar.(send)
times = Array{Float64}(undef, N)
samples = Array{Float64}(undef, N_SAMPLES)

for i ∈ 1:N
   for j ∈ 1:N_SAMPLES
       samples[j] = @elapsed begin
           sreq = MPI.Isend(send[i], rank_r, (i - 1) * nproc + rank, comm)
           rreq = MPI.Irecv!(recv[i], rank_s, (i - 1) * nproc + rank_s, comm)
           MPI.Waitall!([sreq, rreq])
       end
   end
   times[i] = median(samples)
end

MPI.Barrier(comm)
rank == 0 && println("FINISHED GENERATING DATA")

tag_base = N * nproc
if rank == 0
```

```
    all_times = [similar(times) for _ ∈ 1:nproc]
    all_times[1] = times
    for i in 2:nproc
        all_times[i], statrcv = MPI.recv(i - 1, tag_base + (i - 1), comm)
    end
else
    sreq = MPI.send(times, 0, tag_base + rank, comm)
end


MPI.Barrier(comm)
rank == 0 && println("FINISHED GATHERING DATA")

# Data Analysis

if rank == 0
    latency = plot(ylabel="Latency (s)", xlabel="Message Size (bytes)", yaxis=:log,
xaxis=:log, legend=:bottomright)
    bandwidth = plot(ylabel="Bandwidth (bytes/s)", xlabel="Message Size (bytes)", yaxis=:log,
xaxis=:log, legend=:bottomright)
    for i ∈ 1:nproc
        scatter!(latency, sizes, all_times[i], label="rank $(i - 1)")
        scatter!(bandwidth, sizes, sizes ./ all_times[i], label="rank $(i - 1)")
    end
    savefig(latency, "latency.svg")
    savefig(bandwidth, "bandwidth.svg")
end

MPI.Barrier(comm)
rank == 0 && println("FINISHED ANALYZING DATA")
```



Latency vs. message size measured with a sample size of 1000 on four nodes.



Bandwidth vs. message size measured with a sample size of 1000 on four nodes.

Part 2: Interpretation

Based on these plots, the minimum latency is roughly 1 ms, and the maximum bandwidth is roughly 10 GB/second on my computer. My model of CPU has been measured at roughly 25 GFLOPS.[1] Thus the cost of sending a small message is roughly 10,000 operations/byte (25 GFLOPS / 25 bytes/second) whereas the cost of sending a larger message is only about 2.5 operations/byte (25 GFLOPS / 10 GB/second). Clearly, sending fewer large messages is much more efficient than sending many smaller messages.

Part 3: Parallel Bandwidth

Unfortunately I am still waiting for my Supercloud account to be approved. I'll be sure to check out this optional exercise later once I have access to the necessary hardware.

[1] https://www.cpubenchmark.net/cpu.php?cpu=Intel+Core+i7-9750H+%40+2.60GHz&id=3425