Exercise 3 - Theory Answers

1. **Discuss how using MPI Allgather versus MPI Gather will impact performance of a program.**

   MPI_Gather collects data from all processes to a single root process. *MPI_Allgather* collects data from all processes and distributes the result to all processes.

   In terms of performance impact *MPI_Allgather* generally has higher communication overhead because it involves more data transfer while *MPI_Gather* is more efficient when only one process needs the collected data. Nevertheless, *MPI_Allgather* can be beneficial if all processes need the complete data, avoiding additional communication steps.

2. **Let's say we wanted to use a 9-point stencil for approximation on the current time step instead of just 5, as illustrated in Figure 11. How would you communicate the value needed from Rank 2?**

   To communicate the value needed from Rank 2, it would be needed to extend the border exchange to include corner (diagonal) elements. This could be done by finding the diagonal neighbor, where in this case is rank 1, and use point-to-point communication to give the needed value.

3. **Try to run the code with M = 2048 and N = 512. What changes, and why does this happen? (The sequential code will produce the same behavior if you haven't fully implemented the parallel version.)**

   The visible change is that more wave peaks are visible due to the larger grid size. This probably happens because of the aspect ratio change (4:1 instead of 1:1) that affects how the waves propagate and reflect in the domain.

4. **What is the difference between weak scaling and strong scaling?**

- Weak Scaling is the speedup for a scaled problem size with respect to the number of processors (Gustafson's law).

- Strong Scaling is the speedup for a fixed problem size with respect to the number of processors (Amdahl's law).