To: Christina Taylor
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Date: April 10, 2023
Subject: CAAM 420/520 – Homework 4
I collaborated with Arshia Singhal, Jonathan Cangelosi and Prani Nalluri on this homework.

Problem 1

(a) The regions that will be sent by fully-embedded ranks are B, C, D, G and J. They are part of the inner halo. We are working with a backward finite difference stencil so to compute the value of a certain element, we need the elements to the left and the bottom of it.

(b) The regions that will be received by fully-embedded ranks are A and L. They are the halos and the block needs their values to compute the regions B, E, H, I, and J due to the same stencil as in part a.

(c) Communication and computation cannot be overlapped. Since we are working in a spatial not time-dependent domain, we need to work in a wavefront fashion. Thus, computing D (part of the inner halo) for example requires the computation of C and G which depends on B, F, and J, and so on. Thus, we have to compute everything in a wavefront fashion starting from A and L due to the stencil. After finishing all the computations, you can now send the inner halos B, C, D, G and J. We can compute one of B, C, D, G and J at a time and then send it one at a time, but that requires multiple communication and becomes inefficient.

Problem 2

(a) Regarding the send, we should wait for the computation of the inner halo (E, F, G, H, J, K, L, M) even if we have two arrays because otherwise we would be sending the same old values. As for the receive, we don't need to wait for the computation as we have two arrays, so we can receive the new values of B, N, D and P, store them in u_new, and then use the values of u_old to compute the inner halo (E, F, G, H, J, K, L, M).

(b)
- For the packing, vertical inner halos will need to be packed (EHK and GJM) as we have row-major indexing. As for horizontal inner halos (EFG and KLM), we can send a pointer to the rank's main data as the memory will be contiguous due to the indexing. However, if the halo radius is more than one, we will have some extra data that are from N and D.
- For the unpacking, horizontal halos (B and P) do not need to be unpacked as the indexing is row-major so we can directly fill their memory. There will be some extra data that will be stored in A and C (if the halo radius is more than one). On the other hand, vertical halos (D and N) need to be unpacked because their memory is not contiguous.

(c) Since there is no stencil involved, the order will be as follows:

- Post the calls to the halo receives.
- Compute the inner halos in a certain order:
  - We can compute the cheap inner halos first (horizontal inner halos: the ones that do not need packing), pack them and send them one by one (check code).

  - Then, we can compute the more expensive inner halos (vertical inner halos: the ones that need packing), pack them and send them one by one (check code). This will help maximally hide communication as we have more computation now while the previous two sends are being processed.
- Compute the innermost region. This will overlap with the sending of the inner halos.
- Unpack the right and left halos after the receive is over.

(d) Submitted as code.