MONASH University

FIT3143 - Parallel Computing (S2, 2021)

Assignment 2 - Frequently Asked Questions

Note: This document will be periodically updated with new questions and possible revisions to current answers.

Last updated: 16th September 2021 (19 questions)

1. **What if my team consists of three members?**

   A: Scope of the simulator and depth of report will increase:
   a) The team is required to simulate a fault detection and response method, as mentioned in page 3 of the assignment specifications (See Question 10 in this FAQ).
   b) The length of the report increases from max 1,500 words to up to 2,000 words.

2. **What do I need to submit for this assignment?**

   A: Please refer to the submission requirements in pages 6 and 7 of the assignment specifications.

3. **Is each team member required to make a submission in Moodle?**

   A: Yes - individual submission in Moodle. Although you are working in a group of two (or three) members and your code files, report and log files will be the same within a group, each team member is required to make a submission independently in Moodle.

4. **Am I required to understand the science of a Tsunami or engineering details of a tsunameter in order to complete this assignment?**

   A: No - you are not required to have any prior scientific knowledge of Tsunamis or **engineering details of a tsunameter**. You are only required to simulate a wireless sensor node whereby each node generates random sea water column height values and analyse these values to see if they exceed a predefined threshold value. Nevertheless, if you have some time and if you are keen to learn more about the science of a tsunami, please refer to this link or this research paper for further reading.

   You may also refer to this link, which contains an interactive visualization of tsunameter readings around the world, just for your reference.

5. **I have read the assignment specifications. However, I am still not sure how to start the assignment. So, how do I start the assignment?**

A: The following response includes sub-questions with answers:

Let’s say the wireless sensor network comprises 20 nodes **and** a base station. These nodes are arranged in a 4 x 5 (rectangular-shaped) grid as per the tabulated illustration in the following page.

In this example, each node and base station is a Message Passing Interface (MPI) Process, so now you have a total of **21 MPI processes**. Let’s say MPI Rank20 is the base station and the remaining ranks (i.e., Ranks0 - 19) simulate the sensor nodes.

Let’s assume your map/grid looks like the following:

	0	**1**	**2**	**3**	**4**
0	Rank0 (0,0)	Rank1 (0,1)	Rank2 (0,2)	Rank3 (0,3)	Rank4 (0,4)
1	Rank5 (1,0)	Rank6 (1,1)	Rank7 (1,2)	Rank8 (1,3)	Rank9 (1,4)
2	Rank10 (2,0)	Rank11 (2,1)	Rank12 (2,2)	Rank13 (2,3)	Rank14 (2,4)
3	Rank15 (3,0)	Rank16 (3,1)	Rank17 (3,2)	Rank18 (3,3)	Rank19 (3,4)

What are “adjacent nodes”?

All the **immediate neighbours in top-bottom and left-right directions** are “adjacent nodes”. For instance, by referring to the grid layout above:

- For node Rank6 (1,1), adjacent nodes are: Rank1, Rank11, Rank5, Rank7.
- For node Rank10 (2,0), adjacent nodes are: Rank5, Rank15, Rank11.
- For node Rank15 (3,0), adjacent nodes are: Rank10, Rank16.

Communication scheme:

Each node communicates with adjacent nodes directly. Non-adjacent nodes (such as Rank11 and Rank14) can't communicate directly.

Communication between the nodes and base station may take place using any of the following methods:

- Blocking or non-blocking Send/Receive
- Broadcast
- Scatter/Gather
- Any other MPI method that you think is appropriate.

What is an "Event"?

At each sensor node, the program/simulation will iteratively run (until a termination message is received from the base station). Each iteration runs at a *y* time interval (where *y* = you decide). At each iteration:

a) The sensor node will generate a random number to simulate a simulated sea water column height value at a given time. You can specify a range for random number generation to increase the chances of generating higher sea water column height values. Page 4 of the assignment specifications includes sample values for your reference.
b) The generated random values are added to a simple moving average. You can decide the size of the moving average window.
c) If the moving average value exceeds a predefined threshold, this constitutes a possible tsunami event. The node will then send a request to its immediate adjacent neighbourhood nodes to acquire their readings for comparison purposes. To reiterate, the neighbourhood nodes refers to immediate top, bottom, right and left adjacent nodes.
d) Upon receiving sensor readings from its neighbourhood nodes, the node compares these readings to its own readings to check if the readings are similar.
e) Should the readings from at least two or more neighbourhood nodes match the sensor readings of the local node (within a predefined tolerance range), the node sends a report (i.e., alert) to the base station.
f) The report sent to the base station should include information about the time at which an alert is detected, sensor value readings, number of messages compared with the neighbourhood modes, etc. You should demonstrate efficiency when reporting an alert message to the base station. In this context, you should minimize the number of calls to MPI Send or Isend function when reporting an alert to the base station.

g) The sensor node repeats parts (a) to (f) until upon receiving a termination message from the base station. Once the node receives a termination message, the node cleans up and exits.

6. How about the satellite altimeter? What does it do?

A: The information in Page 4 of the assignment specifications should be sufficient to describe the process of simulating the satellite altimeter. To expand a bit more, the thread simulating the satellite altimeter is created by the base station node. The thread runs iteratively (until a termination signal is received from the base station to exit). Each iteration runs at a *y* time interval (where *y* = you decide). At each iteration:

a) The produces two random values:
   i) A sea water column height value which exceeds the pre-defined threshold (e.g., > 6000 meters).
   ii) Coordinates (x, y) within the range of the simulated Cartesian grid layout. For instance, if the simulation runs on a 4 x 5 grid, then the range of Cartesian coordinates is between 0,0 and 3,4. Pages 4 and 5 of the assignment specifications include sample values for your reference.
b) The generated random values are stored in a shared global array, which can also be accessed by the base station node. The array has a fixed size, and you can decide the size of this array.
c) Take note that the size of the global array also determines the size of the time window. For instance, if the thread produces a random sea water column height value at every second and the size of the array is 50, this means that the array can store up to 50 seconds worth of sea water column height values.
d) Once the array is full, the thread removes the first entered data from the array to make way for the new data (first in, first out approach).

7. With reference to the answer for Question 5 above, the suggested approach makes it difficult for the thread simulating the satellite altimeter to generate random sea water column height values that match the reported values from a sensor node. Could I modify the implementation?

A: Yes, you can. You may opt to have the thread periodically generate random sea water column height values for the entire grid, and then push this data into a shared global array, which can be accessed by the MPI process simulating the base station.

This approach could increase the probability of reporting matched alerts into the log file.

8. How about the base station? What does it do?

A: To expand on the specifications of the base station in page 5 of the assignment specifications:

a) The base station is also an MPI process and runs an iterative loop for a number of iterations. The number of iterations is set by you. Each iteration runs at a *y* time interval (where *y* = you decide). Once the number of iterations has been reached, the base station could then issue a termination signal to all sensor nodes and the satellite altimeter. Lastly, shutdown the program.
b) At each iteration, the base station checks for any messages sent by sensor nodes. If the base station receives a message from the sensor node, before logging the message into disk (i.e, writing the message to a log file), the base station needs to first compare the received sensor reading (and timestamp) with that of the readings written into the global array by the satellite altimeter.
c) Continuing from part (b) above, if there is a match (not necessarily has to be an exact match), then the ba loop se station logs the alert into a log file. If there is no match, the base station can also log the alert as a mismatched alert. In your report, you could then include an analysis on the number of true and false alerts.

9. What should a base station log?

A: As much information as possible. Examples include:

- Timestamp of the alert message
- Alert type (Match or Mismatch)
- Reporting Node information
- Adjacent node information
- Infrared satellite reading
- Communication time
- Number of messages sent by reporting node to base station
- Number matching adjacent nodes' sea water column height reading to the reporting node's sea water column reading.

An example of an entry by the base station into the log file:

```
------------------------------------------------------------------------------------------------------
Iteration : 15
Logged time :                   Sun 2021-09-05 19:23:12
Alert reported time :           Sun 2021-09-05 19:23:10
Alert type: Match (or True)

Reporting Node      Coord       Height (m)      IPv4
12                  (2,2)       6102.896        118.139.135.57 (mk02)

Adjacent Nodes      Coord       Height (m)      IPv4
7                   (1,2)       6101.845        118.139.135.57 (mk01)
11                  (2,1)       6200.546        118.139.135.57 (mk02)
13                  (2,3)       6155.897        118.139.135.58 (mk02)
17                  (3,2)       5845.789        118.139.135.58 (mk02)

Satellite altimeter reporting time : Sun 2021-09-05 19:23:01
Satellite altimeter reporting height (m): 6105.258
Satellite altimeter reporting Coord : (2,2)

Communication Time (seconds) : 0.075
Total Messages send between reporting node and base station: 1
Number of adjacent matches to reporting node: 3
Max. tolerance range between nodes readings (m): 100
Max. tolerance range between satellite altimeter and reporting node readings (m): 100
------------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------------
Iteration : 16
Logged time :                   Sun 2021-09-05 20:04:15
Alert reported time :           Sun 2021-09-05 20:04:01
Alert type: Mismatch (or False)

Reporting Node      Coord       Height (m)      IPv4
5                   (1,0)       6595.155        118.139.135.58 (mk01)

Adjacent Nodes      Coord       Height (m)      IPv4
0                   (0,0)       6550.89         118.139.135.59 (mk01)
6                   (1,1)       6701.89         118.139.135.60 (mk01)
10                  (2,0)       6624.29         118.139.135.60 (mk01)

Satellite altimeter reporting time : Sun 2021-09-05 20:04:05
Satellite altimeter reporting height (m): 5125.258
Satellite altimeter reporting Coord : (1,0)

Communication Time (seconds) : 0.085
Total Messages send between reporting node and base station: 1
Number of adjacent matches to reporting node: 3
Max. tolerance range between nodes readings (m): 100
Max. tolerance range between satellite altimeter and reporting node readings (m): 100

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```

At the end of the program, the base station writes a summary into the log file. Examples include:

- Number of messages passed throughout the network when an alert is detected.
- Number of alerts (true and false) occurred throughout the network.
- Total communication time.

Note: Writing these metrics to a log file would help us evaluate the efficiency and correctness of your program. Hence, try to log as much useful information as possible. In addition, you are not required to exactly follow the example log file entry as aforementioned. You can determine your own format of entry, so long as the log file contains useful information.

10. **What about the fault detection requirements for this assignment?**

A: **This requirement applies to teams of three members**. You should design and implement a fault detection algorithm whereby a sudden failure of a node is detected by the base station and/or adjacent nodes. You may choose to select and implement a fault detection algorithm of your choice. More importantly, should a fault be detected, your model should demonstrate a response to it. This response includes proper logging of the node(s) failure and graceful shutdown of the entire network. You need to report this in the report and demonstrate it during the code interview in Week 12.
Note: If you belong to a team of two members, you are not required to implement fault detection.

11. **Are there any sample reports as a reference?**

A: Yes, we have included two sample reports (from 2019) as a reference in the Assessment section in Moodle. Please note that the requirements in last year's reports are substantially different from this year's report. As such, please consider the sample reports as a reference to give you an indication of what to write in your actual report.

12. **Could I expand the scope of the assignment? For instance, I would like to expand the scope of the assignment whereby each node is also able to indirectly communicate with non-immediate adjacent nodes via the base station. Is this allowed?**

A: The requirements in the assignment specifications serve as a baseline on the outcomes of the simulation model. If you have the motivation to expand the scope of the assignment further (e.g, including visualisation of the reported possible tsunamis on an artificial map), we certainly do encourage you to pursue this. However, please bear in mind that the baseline requirements of the assignment need to be fulfilled.

13. In terms of performance, what do I need to measure for this assignment?

A: To clarify, this assignment does not focus on data parallelism. Hence, there is no need to compute theoretical speed up and actual speed up. Instead, this assignment focuses on inter process communication (IPC) using Message Passing Interface (MPI) and asynchronous computing using thread(s). As such, you could consider measuring the following:

a) Communication time between adjacent nodes.
b) Communication time between the reporting node and the base station.

Based on the logged communication, you can then carry out an analysis of your implemented design based on its efficiency. You are also encouraged to run your program on MonARCH to obtain a more representative communication time when running the program across multiple processors.

14. My personal computer (or virtual machine) has a limited number of processors. How am I supposed to obtain a representative performance analysis?

A: As highlighted in the preceding question, this assignment focuses on IPC and asynchronous computing using thread(s). Although you are required to demonstrate a dynamic range of m and n values for the grid, you can start by using small values for m and n (e.g. m = 3, n = 3), and then gradually increase the values of m and n. You can then repeat this step using MonARCH and compare the communication performance between the local computer and the MonARCH cluster platform. Bear in mind that each MPI process (simulating the sensor node or base station) will execute an iterative loop with an interval between each iteration. Adding this interval actually reduces the computing load on your computer and allows you to run a higher number of MPI processes for this assignment.

15. Can each sensor node keep an individual log file?

A: In the assignment specifications, the base station is required to log alerts (either true or false alerts). Nevertheless, for the purpose of debugging, each node can also keep a node specific log file.

16. Can I use OpenMP thread instead of POSIX thread to simulate the satellite altimeter?

A: Yes you can Open Multi-Processing (OpenMP) to simulate the satellite altimeter.

17. I am new to technical writing. How do I start writing the assignment report?

A: The following table provides a sample guidance on information to include into your report.

<table>
<tr>
<td>1</td>
<td>Cover sheet</td>
<td>
a) Please include the Faculty’s group assignment cover sheet as the first page of your report.

b) Inside the cover sheet and next to your student ID(s), please specify the percentage of your contribution to the assignment. For instance:

SAMPLE
MONASH University
Information Technology

GROUP ASSIGNMENT COVER SHEET
<table>
<tr><th>Student ID Number</th><th>Surname</th><th>Given Names</th></tr>
<tr><td>201456999 (50%)</td><td>Smith</td><td>Alice</td></tr>
<tr><td>201666789 (50%)</td><td>Anderson</td><td>John</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
</table>
* Please include the names of all other group members.
<table>
<tr><td>Unit name and code</td><td colspan="3">Parallel Computing - FIT3143</td></tr>
<tr><td>Title of assignment</td><td colspan="3">Assignment 2. Report title: Design and implementation of a distributed ...</td></tr>
<tr><td>Lecturer/tutor</td><td colspan="3">Vishnu Monn / ABM Russel / Lab Tutor Name</td></tr>
<tr><td>Tutorial day and time</td><td>Specify your lab day and time</td><td>Campus</td><td>Clayton/Malaysia</td></tr>
</table>
c) Try to include the cover sheet as an image into your report.
</td>
</tr>
<tr>
<td>2</td>
<td>Title</td>
<td>
a) Create a simple title which best fits your assignment. For instance: Design and implementation of a distributed wireless sensor network simulator to detect possible tsunamis.

b) Ensure that your name(s) and e-mail addresses are written under the title.

c) Please include an estimated word count of your report.
</td>
</tr>
</table>

3	Methodology	a) Specify in detail the design and implementation of the simulated wireless sensor network node. b) Include an illustration of a grid network to provide a clear idea of the architecture. You can refer to the sample illustrations in the assignment specifications and in the FAQ. However, please draw your own version of it. c) You can divide the design section into several subsections to describe each simulated component. For instance: i) Subsection A: Sensor node. ii) Subsection B: Satellite altimeter iii) Subsection C: Base station. d) For each sub-section above, include flowcharts and/or pseudo code or mathematical equations (if any) to describe the algorithm or design of your entire simulator. You could also include a diagram illustrating what type of information is packed into a single data for transmission to the base station. There are no restrictions on the type and number of diagrams and/or pseudocode to be included in the report, provided this additional information adds value to your report. Ensure the information mentioned in this section covers the requirements mentioned in the assignment specifications for the sensor node, base station and infrared imaging satellite. You may refer to the sample reports in Moodle for some reference. e) Provide an explanation of the diagrams, flowcharts and/or pseudocode in the subsection. For instance: *Figure 2 illustrates the method of requesting and exchanging sea water column values between a sensor node and its adjacent nodes. In this figure, the sensor node first sends a request message to the adjacent nodes...* Avoid just including the aforesaid diagrams/pseudocode without proper explanation. The explanation is important to justify the selection of the design approach in simulating the sensor network.

4	Results tabulation	a) Include a brief subsection to provide details on the simulation experiment setup. Here, you can specify the following: i) Platform tested on (local/virtual machine or MonARCH, both of any other platform) ii) Specifications of the platform (i.e., number of available logical processors, system memory, CPU frequency, network bandwidth (this applies if you are testing on a cluster), IP address. iii) Specification of each test run (i.e., size of the grid, sea water column height threshold, number of iterations at the base station). You should test with different grid sizes. iv) Number of runs per test specification. b) In the next subsection, tabulate results of the test run. You may also include graph(s) depicting the performance of the sensor node for an increasing grid size or the performance of the base station for an increasing number of reported alerts. You should also include screenshots of the log files and a table summarizing the outcome of each simulation and proper termination of all nodes at the end of the simulation.
5	Analysis and discussion	a) Analyse and discuss the tabulated results. Provide an observation on the behaviour of the sensor network for different grid sizes or when tested on different platforms (e.g., on MonARCH). b) Discuss possible limitations based on the tabulated results and suggest methods which could be undertaken to address these limitations as part of future work.
As a whole, your report resembles an experiment on simulating the wireless sensor node as per the assignment specifications. Please do not be alarmed by the information above. This information is here to help you write the report. If you refer to the steps above, you should be able to complete the report in a timely manner. Note that a lengthy report does not necessarily mean that you will get higher marks. Therefore, keep your report concise.		

18. **In Section 1 (or Part 1) of Assignment 2 Rubric (Demo + Q&A), I do not understand the following criteria: "*B) On top of High Distinction, for Upper HD (i.e., above 90%): - A node uses a thread (i.e., POSIX or OPENMP) to send or receive MPI messages between its adjacent nodes. This thread is created by the sensor node and terminates properly at the end of the program*."**

A: In Simulating the tsunameter sensor node, each sensor node represents a MPI process. This is mentioned in the assignment specifications and also in Question 5 of this FAQ.

Recall that if the moving average value of a node exceeds a predefined threshold, this constitutes a possible tsunami event. The node will then send a request to its immediate adjacent neighbourhood nodes to acquire their readings for comparison purposes. Upon receiving sensor readings from its neighbourhood nodes, the node compares these readings to its own readings to check if the readings are similar. You should be able to complete these tasks within a MPI process which simulates a tsunameter sensor node.

However, the sensor node can also create a POSIX (or OpenMP) thread to send or receive MPI messages between its adjacent nodes. This represents a form of a hybrid MPI-thread approach for a sensor node. We have done a similar exercise (albeit a simpler version) in Lab Week 7. Therefore, we have included this criteria here, especially if you are aiming for an Upper HD score for Section 1 of the Assignment 2 rubric (Demo + Q&A).

19. **In Section 3 (or Part 3) of Assignment 2 Rubric (Demo + Q&A), I do not understand the following criteria: "*B) On top of High Distinction, for Upper HD (i.e., above 90%): - The base station uses a thread (i.e., POSIX or OPENMP) to send or receive MPI messages from the sensor nodes. This thread is created by the base station and terminates properly at the end of the program.*"**

    A: The base station represents a MPI process. This is mentioned in the assignment specifications and also in Question 8 of this FAQ.

    Recall that at each iteration, the base station checks for any messages sent by sensor nodes. You should be able to complete this task within a MPI process which simulates the base station.

    However, the base station can also create a POSIX (or OpenMP) thread to send or receive MPI messages from the sensor nodes. This represents a form of a hybrid MPI-thread approach for a base station. We have done a similar exercise (albeit a simpler version) in Lab Week 7. Therefore, we have included this criteria here, especially if you are aiming for an Upper HD score for Section 3 of the Assignment 2 rubric (Demo + Q&A).