MONASH University

FIT3143 - Parallel Computing (S2, 2022)

Assignment 2 - Frequently Asked Questions

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

Last updated: 8th September 2022 (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 5 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 seismology or engineering details of a seismometer in order to complete this assignment?**

   A: No - you are not required to have any prior scientific knowledge of seismology or engineering details of a seismometer. You are required to simulate a wireless sensor node whereby each node generates random seismic values and analyse these values to see if they exceed a predefined threshold value. Nevertheless, general knowledge on earthquakes and geographical coordinates which you learnt in high-school could be applied here. if you have some time and if you are keen to learn more about the seismology, please refer to this link or this YouTube video. The assignment specifications also include several embedded links on real-time seismic readings and research papers on seismology 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 random seismic readings at a given time. You can specify a range for the random number generator to increase the chances of generating seismic readings which would exceed a threshold value. Page 4 of the assignment specifications includes sample values for your reference.
b) If the generated magnitude at each time interval average exceeds a predefined threshold (e.g., magnitude > 2.5), this constitutes a possible earthquake 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.
c) Upon receiving sensor readings from its neighbourhood nodes, the node compares these readings to its own seismic readings to check if the readings are similar. Comparisons here are based on:
   i) Computing the distance (i.e., latitude and longitude coordinates).
   ii) The earthquake magnitude readings.
d) Should the distance and magnitude from at least two or more neighbourhood nodes match the reading of the local node (within a threshold which you can determine), the node sends a report (i.e., alert) to the base station. To compute the distance between two geographical coordinate points in C, you may refer and use the code in this link with proper citation to the code in your report.
e) The report sent to the base station should contain as much information as possible about the possible alert. This information includes the timestamp (including the date & time) at which an alert is detected, sensor value

readings (e.g., magnitude, depth, location) and number of messages compared with the neighbourhood nodes. You should demonstrate efficiency when reporting an alert message to the base station. In this context, you should minimise the number of calls to the MPI Send or Isend functions by a node to the base station when reporting an alert condition.

f) 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 balloon seismic sensor? What does it do?**

   A: The information in Page 5 of the assignment specifications should be sufficient to describe the process of simulating the balloon seismic sensor. To expand a bit more, the thread simulating the balloon seismic sensor 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) This thread periodically produces seismic readings. This reading consists of date, time, latitude and longitude of the earthquake point, magnitude, and depth of the quake from the sensor. However, the generated magnitude always exceeds the predefined threshold. Page 5 of the assignment specifications includes 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 seismic readings at every second and the size of the array is 50, this means that the array can store up to 50 seconds worth of seismic readings.
   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 6 above, the suggested approach makes it difficult for the thread simulating the balloon seismic sensor to generate random seismic readings 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 generate fixed seismic readings, 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 conclusive 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 ballon seismic sensor. 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 balloon seismic sensor.
   c) Continuing from part (b) above, if there is a match (not necessarily has to be an exact match), then the base station logs the alert into a log file. If there is no match, the base station can also log the alert as a inconclusive alert. In your report, you could then include an analysis on the number of conclusive and inconclusive 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
   - Balloon seismic reading
   - Communication time
   - Number of messages sent by reporting node to base station
   - Number matching adjacent nodes' seismic readings to the reporting node's seismic readings (i.e., comparing the computed distance and earthquake magnitudes).

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

```
--------------------------------------------------------------------------------------------------------------
Iteration : 15
Logged time :                Sun 2022-09-05 19:23:12
Alert reported time :        Sun 2022-09-05 19:23:10
Alert type: Conclusive

Reporting Node    Seismic Coord                       Magnitude                 IPv4
12 (2,2)          (-15.37,167.49)                     4.50                      118.139.135.57 (mk02)

Adjacent Nodes    Seismic Coord       Diff(Coord, km) Magnitude     Diff(Mag)   IPv4
7 (1,2)           (-15.38,167.51)     2.42            4.75          0.25        118.139.135.57 (mk01)
11 (2,1)          (-15.40,167.41)     9.20            4.60          0.10        118.139.135.57 (mk02)
13 (2,3)          (-15.35, 167.55)     6.81           4.25          0.25        118.139.135.58 (mk02)
17 (3,2)          (-15.45, 168.11)     67.05          4.55          0.05        118.139.135.58 (mk02)

Balloon seismic reporting time : Sun 2022-09-05 19:23:01
Balloon seismic reporting Coord: (-15.30, 167.60)
Balloon seismic reporting Coord Diff. with Reporting Node (km): 14.13
Balloon seismic reporting Magnitude: 4.55
Balloon seismic reporting Magnitude Diff. with Reporting Node: 0.05

Communication Time (seconds) : 0.075
Total Messages send between reporting node and base station: 1
Number of adjacent matches to reporting node: 3
Coordinate difference threshold (km): 20
Magnitude difference threshold: 0.50
Earthquake magnitude threshold: 2.50
--------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------------------------------------------------------
```

In the example log above:

- Node 12 reports an alert to the base station.
- The location of seismic readings for nodes 7, 11, 13 and 17 are 2.42km, 9.20km, 6.81km and 67.05km away from the location of the seismic reading recorded by node 12.
- In addition, the magnitude of seismic readings for nodes 7, 11, 13 and 17 differ from node 12's reported magnitude by 0.25, 0.10, 0.25 and 0.05, respectively.
- Coordinate difference threshold is 20 km and Magnitude difference threshold is 0.50
- In this context, at least three (3) neighbourhood nodes (i.e., nodes 7, 11 and 13) recorded similar seismic readings with node 12, and hence node 12 reported an alert to the base station.
- At the same time of reporting an alert, the Balloon seismic sensor reported an earthquake at a location which is 14.13km away from node 12 and a magnitude difference of 0.05. Using the aforementioned thresholds, a conclusive error was reported.

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 poss ible. 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: Unfortunately no. Your report would follow an e-folio template. Based on your lab training, you should be able to produce a report for this assignment. Nevertheless, if you would require some guidance to get started in the report, please refer to Q17 below.

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 earthquakes 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 CAAS 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 CASS and compare the communication performance between the local computer and the CASS 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 balloon seismic sensor?

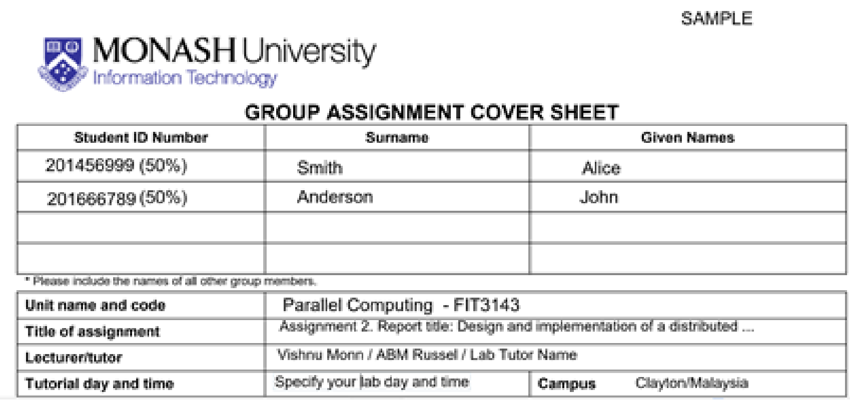
A: Yes you can Open Multi-Processing (OpenMP) to simulate the balloon seismic sensor.

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 underwater earthquakes.

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: Seafloor Sesimic sensor node. ii) Subsection B: Ballon seismic sensor 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 balloon seismic sensor. 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 seismic readings 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 CAAS, 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, seismic thresholds, 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 summarising 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. The derived inference is compared against one hypothesis (i.e., a theory or assumption). You may consider one of the following hypothesis in your report (you may opt to use them verbatim): i) For a given grid size, the communication time measured by the base station increases linearly (or non-linearly) for an increasing number of simultaneous reported alerts by seismic sensor nodes, or ii) For an increasing number of simultaneous reported alerts by the seatwer seismic sensor nodes, the timestamp of an alert message from the sensor nodes may no longer match the timestamp of the seismic readings produced by the balloon seismic sensor, or iii) The amount of communication with the base station will be most dense in the middle of the grid due to an increased number of neighbours and communication between the nodes leading to a higher chance of successful event detection, or We also **encourage** you to include any other hypothesis into your report and then analyse your results based on the hypothesis. b) Provide an observation on the behaviour of the sensor network for different grid sizes or when tested on different platforms (e.g., on CAAS). c) 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 Point 1.0 (i) of the Assignment 2 specifications, I do not understand the following criteria: "*If you are aiming for HD or upper HD: The 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 seafloor seismic 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 generated magnitude of a node exceeds a predefined threshold, this constitutes a possible earthquake 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 seismic 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. However, note that completing this criteria alone does not guarantee an HD or Upper HD score for your assignment.

19. **In Point 3.0 (h) of the Assignment 2 specifications, 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. However, note that completing this criteria alone does not guarantee an HD or Upper HD score for your assignment.