BIC10103

DISCRETE STRUCTURE

SEMESTER 1 / 20222023

FINAL REPORT

Title	:	Minimum Path Linking Kuala Lumpur and Singapore by High-Speed Rail
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1.1 Project Background

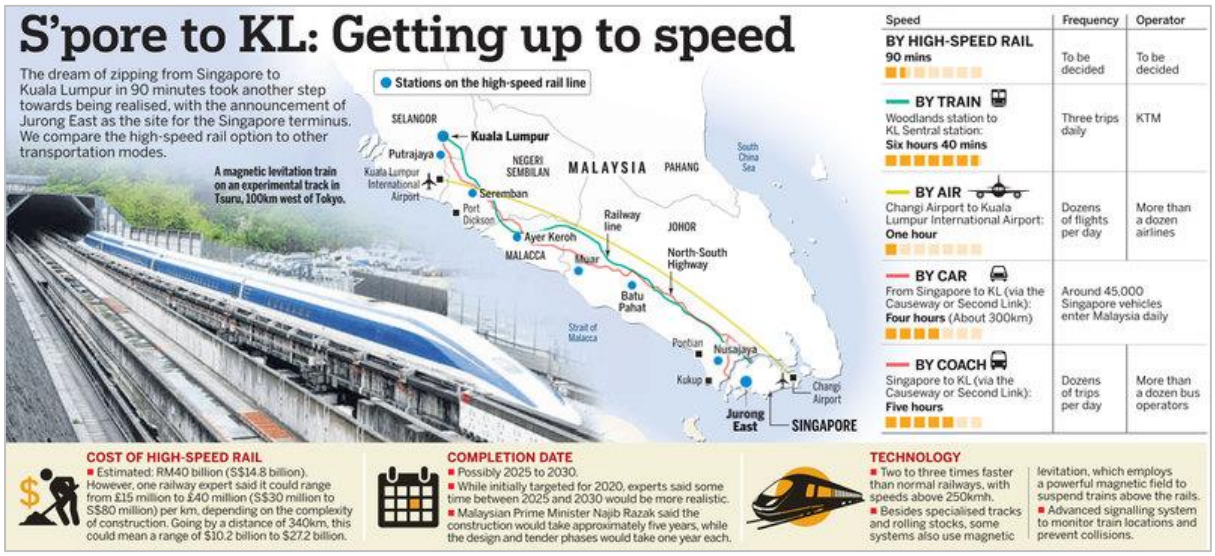

Figure 1.1: Problem Trigger

The Kuala Lumpur-Singapore high-speed rail (HSR) was a proposed train route that would connect Singapore with Kuala Lumpur in Malaysia via a high-speed rail line. Najib Razak, the former prime minister of Malaysia, made the initial proposal in September 2010. The collaborative project was officially approved in February 2013 by Singapore Prime Minister Lee Hsien Loong, with the HSR's initial completion date set for 2026. The HSR line would have been 350 km long and was expected to reduce travel time between Kuala Lumpur and Singapore to 90 minutes. It would have departed from Bandar Malaysia in Kuala Lumpur and connected with other towns along the west coast of West Malaysia on its way to Jurong East in Singapore. Cities along the way would have included Malacca and Seremban.

1.2 Mathematical Problem

Based on the project trigger, a mathematical model is developed to find the minimum path linking Kuala Lumpur and Singapore for a High-Speed Rail (HSR) project by implementing discrete structures, which are graphs and algorithms.

1.3 Objective

The objectives of the project are:

i. To develop a mathematical modelling using the concept of discrete structure for the High-Speed Rail (HSR) project.
ii. To develop a system to find the minimum path linking Kuala Lumpur and Singapore through the High-Speed Rail (HSR).
iii. To analyse the result obtained from the High-Speed Rail (HSR) system.

1.4 Scope

The scopes of the project are stated as below:

- The software to be produced is the High-Speed Rail (HSR) System.
- The software product will calculate and display the distance, duration, and fare for each of the Path.
- The software product is coded using Java Programming Language.

1.5 Overview

The Kuala Lumpur-Singapore High-Speed Rail (HSR) was a proposed transportation project that aimed to connect Kuala Lumpur, the capital city of Malaysia, with Singapore via a high-speed rail line. The project was first proposed by Malaysia's former prime minister, Najib Razak, in September 2010 and was officially approved by the prime minister of Singapore, Lee Hsien Loong, in February 2013. The planned completion date for the HSR was 2026. The rail line was expected to be approximately 350 km long and would have reduced travel time between Kuala Lumpur and Singapore to 90 minutes. It would have started in Bandar Malaysia in Kuala Lumpur and passed through various towns along the west coast of Malaysia on its way to Jurong East in Singapore, including Malacca and Seremban.

CHAPTER 2

RESEARCH

2.1 High-Speed Rail (HSR) Project Detail

The Kuala Lumpur-Singapore High Speed Rail was planned as part of the Economic Transformation Programme, which aimed to make Malaysia a high-income country. The KL-SG HSR is an alternative transportation mode linking two of Southeast Asia's most dynamic and quickly expanding economic engines.

The project was planned as a 350 km double-track route (335 km of which were to be in Malaysia and 15 km in Singapore), with eight stops in total which includes Kuala Lumpur, Putrajaya, Seremban, Ayer Keroh, Muar, Batu Pahat, Nusajaya and Singapore. It is stated that a non-stop, high-speed rail service would run every 30 minutes from Bandar Malaysia, on the outskirts of Kuala Lumpur's city centre, to Jurong East in Singapore. It was expected that the service will operate ten cars-long trains with a capacity for up to 100 passengers per car at average speeds of 300 km/h, cutting the rail travel time between KL and Singapore to 90 minutes with a reasonable fee that is more comfortable and quicker than taking an overnight train or an intercontinental bus, and beats the inconvenience of travelling to the airport and flying.

2.2 HSR Stations Location

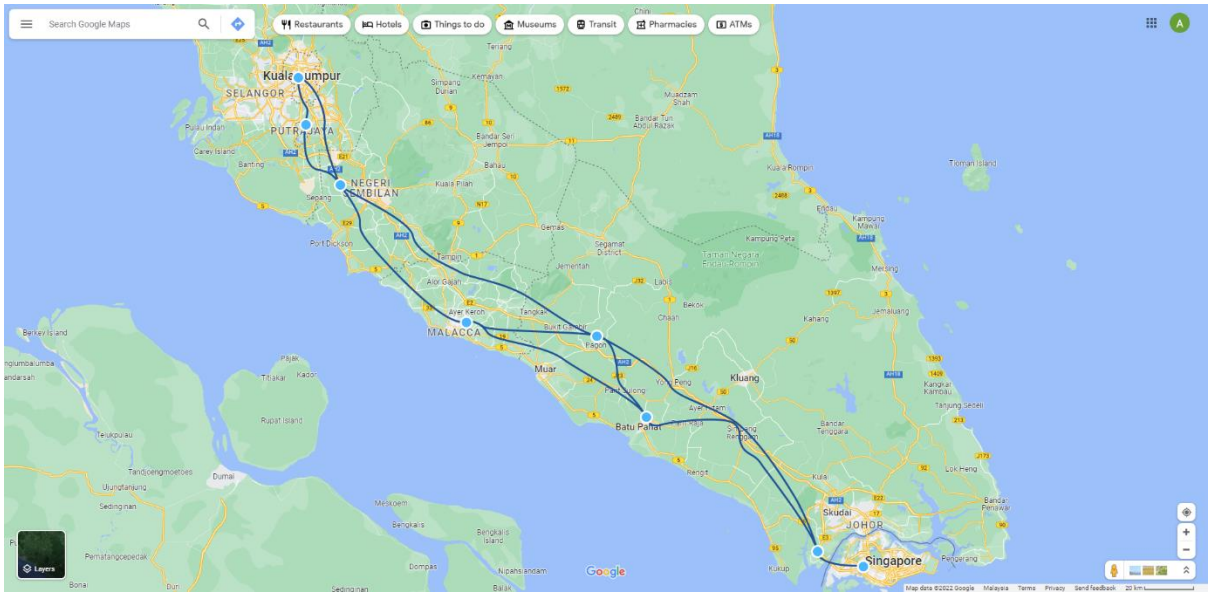

Figure 2.1: HSR Station Location

Figure 2.1 shows the High-Speed Rail (HSR) stations from the Google Maps view. Each blue circle represents HSR stations, which are Kuala Lumpur, Seremban, Ayer Keroh, Muar, Batu Pahat, Nusajaya, and Jurong East. Each route is highlighted in a dark blue line.

2.2.1 Station Code

Table 2.1: Station Code

No.	Station Name	Station Code
1	Kuala Lumpur	KL
2	Putrajaya	PJ
3	Seremban	SR
4	Ayer Keroh	AK
5	Muar	MU
6	Batu Pahat	BP
7	Nusajaya	NS
8	Singapore	SG

Table 2.1 shows the station code for each station.

2.2.2 Kuala Lumpur Station

Kuala Lumpur (KL) station is located at Bandar Malaysia, Kuala Lumpur, and it is the initial station of the High-Speed Rail (HSR). The Kuala Lumpur (KL) station is connected to Putrajaya (PJ) and Seremban (SR) stations.

2.2.3 Putrajaya Station

Putrajaya (PJ) station is located at Kampung Abu Bakar Baginda, Putrajaya, which connects to Kuala Lumpur (KL) and Seremban (SR) station.

2.2.4 Seremban Station

Seremban Station (SR) is located at Labu, Seremban, Malaysia, which connects to Kuala Lumpur (KL) station, Putrajaya (PJ) station, and also Ayer Keroh (AK) and Muar (M) stations.

2.2.5 Ayer Keroh Station

Ayer Keroh (AK) station (SR) is located at Ayer Keroh, Melaka, Malaysia, which connects Seremban (SR) station, Batu Pahat (BP) and Muar (M) station.

2.2.6 Muar Station

Muar (MU) station is located at Bandar Universiti, Pagoh, which connects Seremban (SR) station, Ayer Keroh (AK) station, and also Batu Pahat (BP) and Nusajaya (NS) stations.

2.2.7 Batu Pahat Station

Batu Pahat (BP) station is located at Pura Kencana, Sri Gading, which connects Muar (MU) station, Ayer Keroh (AK) station, and Nusajaya (NS) station.

2.2.8 Nusajaya Station

Nusajaya (NS) station is located at Gerbang Nusajaya, Iskandar Puteri, which connects Muar (MU) station, Batu Pahat (BP) station, and Jurong East (JE) station.

2.2.9 Jurong East Station

Jurong East (JE) station is located at Jurong East, Singapore, and it is the destination station of the High-Speed Rail (HSR). Jurong East (JE) station is connected to Nusajaya (NJ) station.

2.3 Construction of Mathematical Model

2.3.1 Weighted Graph Model

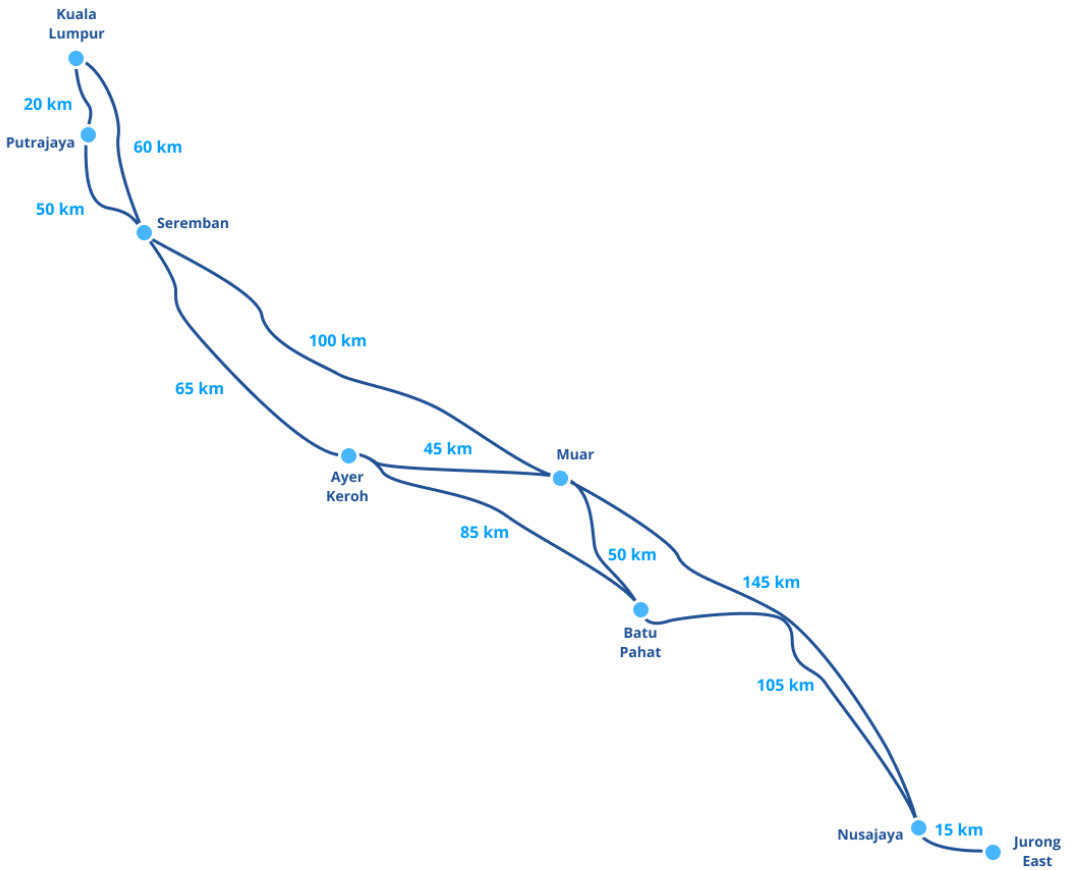

Figure 2.2: Weighted Graph Model

Figure 2.2 shows the weighted graph modelling the High-Speed Rail (HSR) route from Kuala Lumpur to Singapore. In this project, the issues are represented as graphs with weights on each edge. The graph model represents HSR stations as the vertices, and the distance between stations is assigned in kilometres to the edges.

2.3.2 Euler Path and Euler Circuit

In graph theory, a Euler path is a path in a graph that uses every edge exactly once. An Euler circuit is a circuit that uses every edge exactly once, starting and ending at the same vertex. An undirected graph has a Euler path if and only if it is connected and has at most two vertices with odd degrees, and a Euler circuit if and only if it is connected and every vertex has an even degree. A directed graph has a Euler path if and only if it is strongly connected and has at most one vertex with outdegree - indegree not equal to zero, and a Euler circuit if and only if it is strongly connected and every vertex has equal outdegree and indegree. This research will test to find Euler Paths and Euler Circuits based on the High-Speed Rail (HSR) route from Kuala Lumpur to Singapore and determine if Euler Path and Euler Circuit exist in this project.

2.3.3 Hamilton Path and Hamilton Circuit

In graph theory, a Hamilton path (or traceable path) is a path in an undirected or directed graph that visits each vertex exactly once. A Hamilton circuit is a Hamilton path that is a circuit, meaning it starts and ends on the same vertex. Finding whether such paths and circuits exist in a graph is the Hamilton path problem, which is NP-complete. However, there are efficient algorithms that can determine whether a Hamilton circuit exists in a graph or find a Hamilton path in a graph if one exists. This research will test for Hamilton Path and Hamilton Circuit based on the High-Speed Rail (HSR) route from Kuala Lumpur to Singapore and determine if Hamilton Path and Hamilton Circuit exist in this project.

2.4 Distance Between Stations

Table 2.2: Distance Between Stations

No.	Route	Distance (km)
1	KL - PJ	20
2	KL - SR	60
3	PJ - SR	50
4	SR - AK	65
5	SR - MU	100

6	AK - MU	45
7	AK - BP	85
8	MU - NS	145
9	MU - BP	50
10	BP - NS	105
11	NS - JE	15

Table 2.2 shows the distances between stations for each route.

2.5 Path from Kuala Lumpur to Singapore

Table 2.3: Total Distance of Each Path

No.	Path	Total Distance (km)
1	KL - PJ - SR - AK - MU - BP - NJ - JE	350
2	KL - PJ - SR - AK – MU - NJ - JE	340
3	KL - PJ - SR - AK - BP - NJ - JE	340
4	KL - PJ - SR - MU - BP - NJ - JE	340
5	KL - PJ - SR - MU - NJ - JE	330
6	KL - SR - AK - MU - BP - NJ - JE	340
7	KL - SR - AK - MU - NJ - JE	330
8	KL - SR - AK - BP - NJ - JE	330
9	KL - SR - MU - BP - NJ - JE	330
10	KL - SR - MU - NJ - JE	320

According to the mathematical model, there are ten routes that can be chosen to get from Kuala Lumpur to Singapore by using the High-Speed Rail. Table 2.3 shows the route for each path and its distance in kilometres.

2.5.1 Path 1

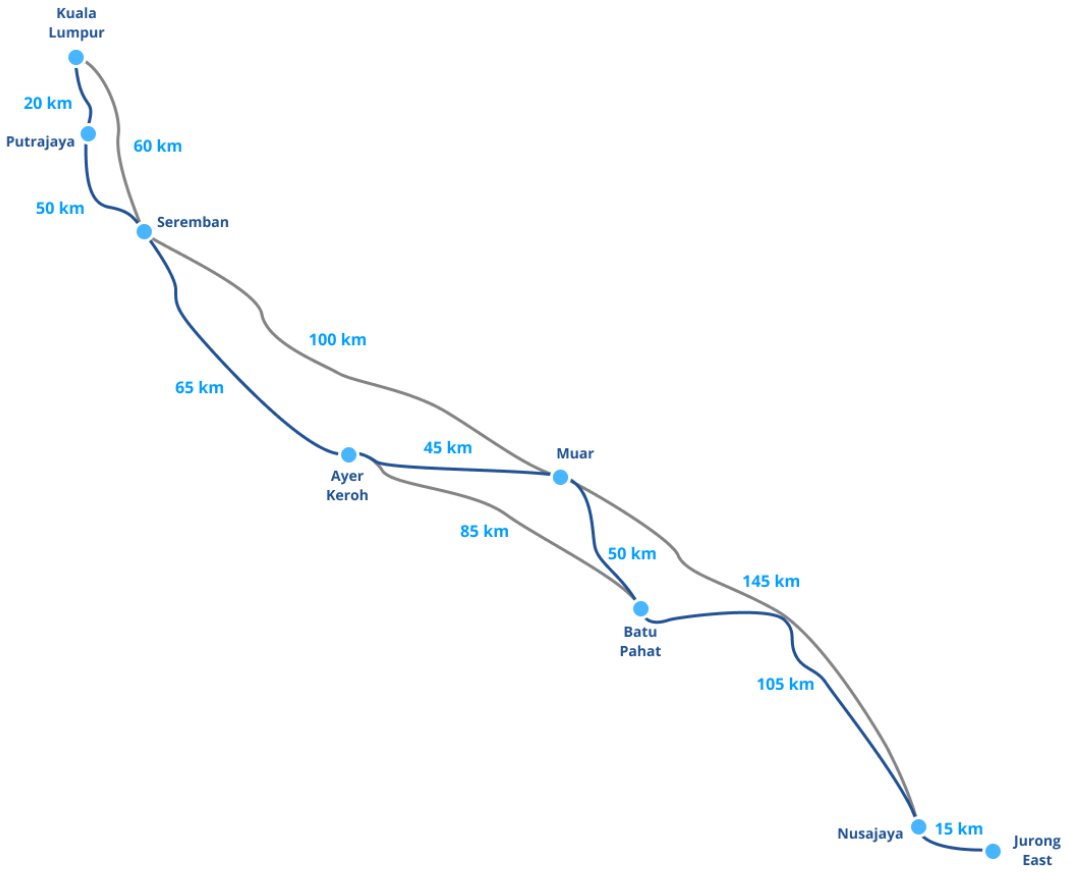

Figure 2.3: Path 1

Figure 2.3 shows the route for Path 1 or the main route for the High-Speed Rail (HSR). The route for Path 1 is highlighted in blue which connects Kuala Lumpur, Putrajaya, Seremban, Ayer Keroh, Muar, Batu Pahat, Nusajaya, and Jurong East.

2.5.2 Path 2

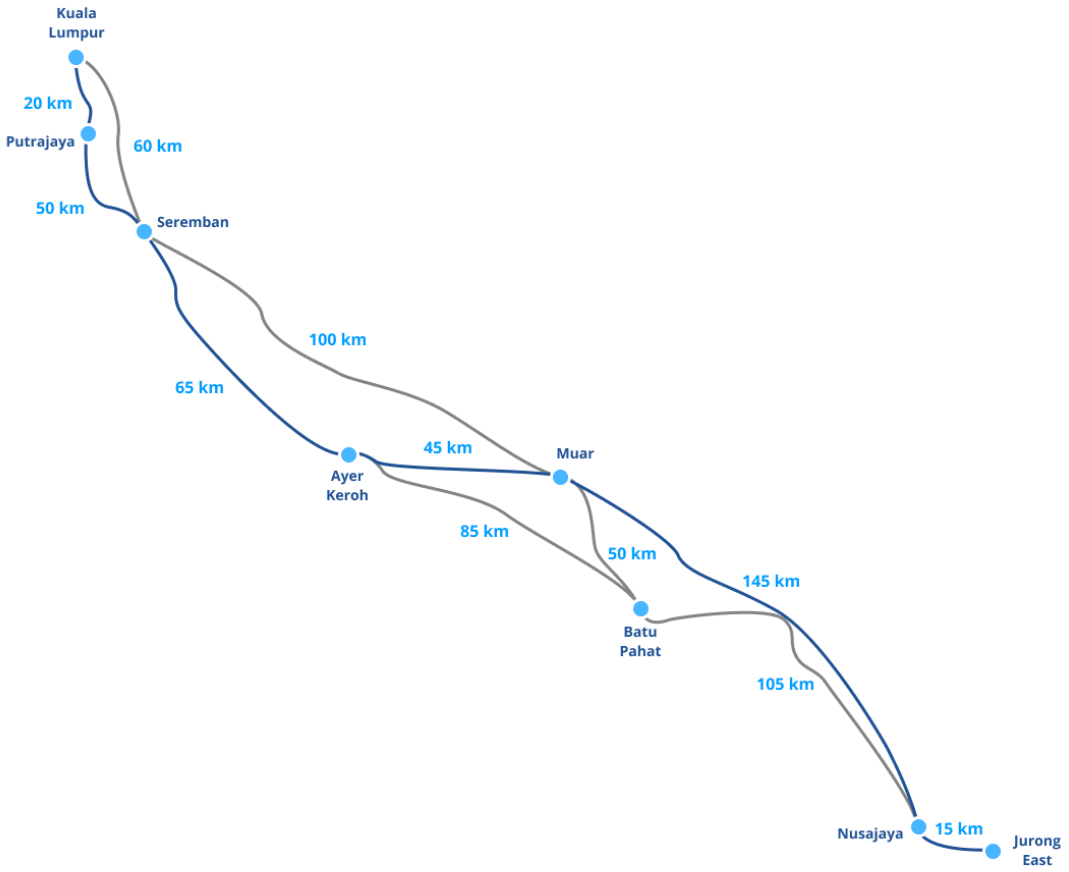

Figure 2.4: Path 2

Figure 2.4 shows the route of Path 2 for the High-Speed Rail (HSR). The route for Path 2 is highlighted in blue which connects Kuala Lumpur, Putrajaya, Seremban, Ayer Keroh, Muar, Nusajaya, and Jurong East.

2.5.3 Path 3

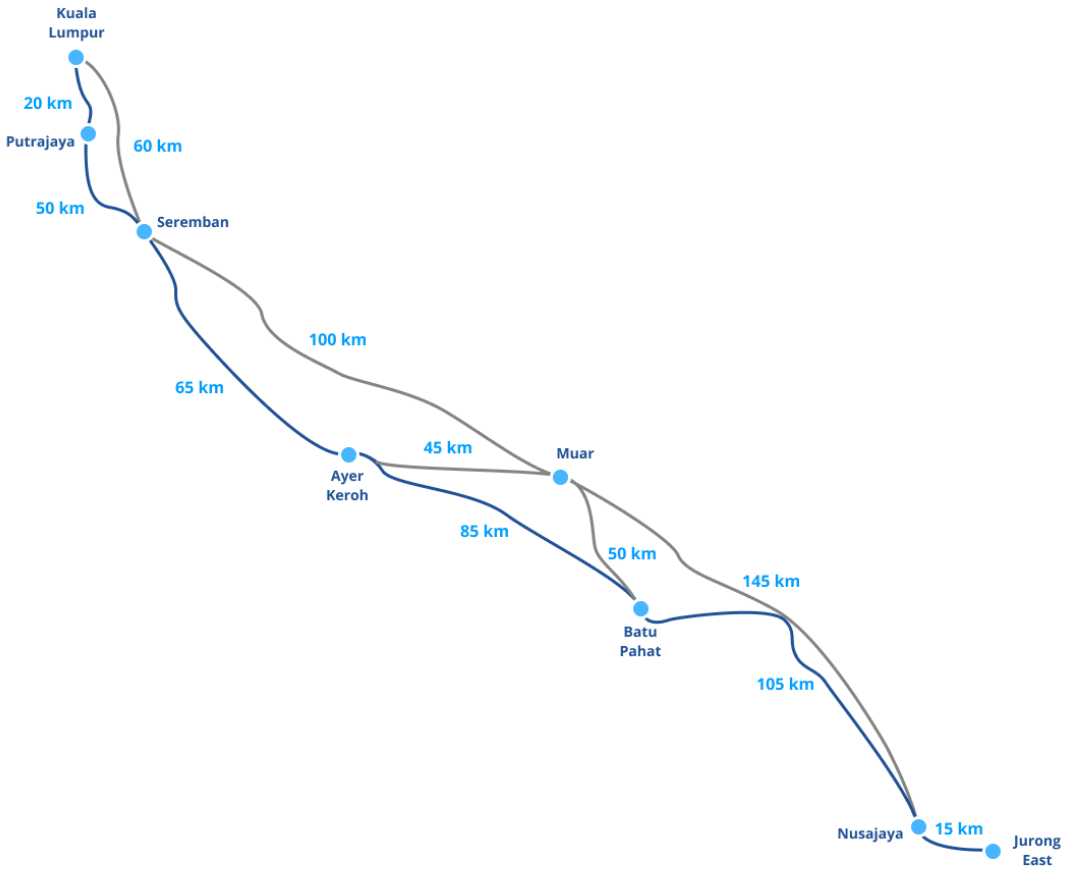

Figure 2.5: Path 3

Figure 2.5 shows the route of Path 3 for the High-Speed Rail (HSR). The route for Path 3 is highlighted in blue which connects Kuala Lumpur, Putrajaya, Seremban, Ayer Keroh, Batu Pahat, Nusajaya, and Jurong East.

2.5.4 Path 4

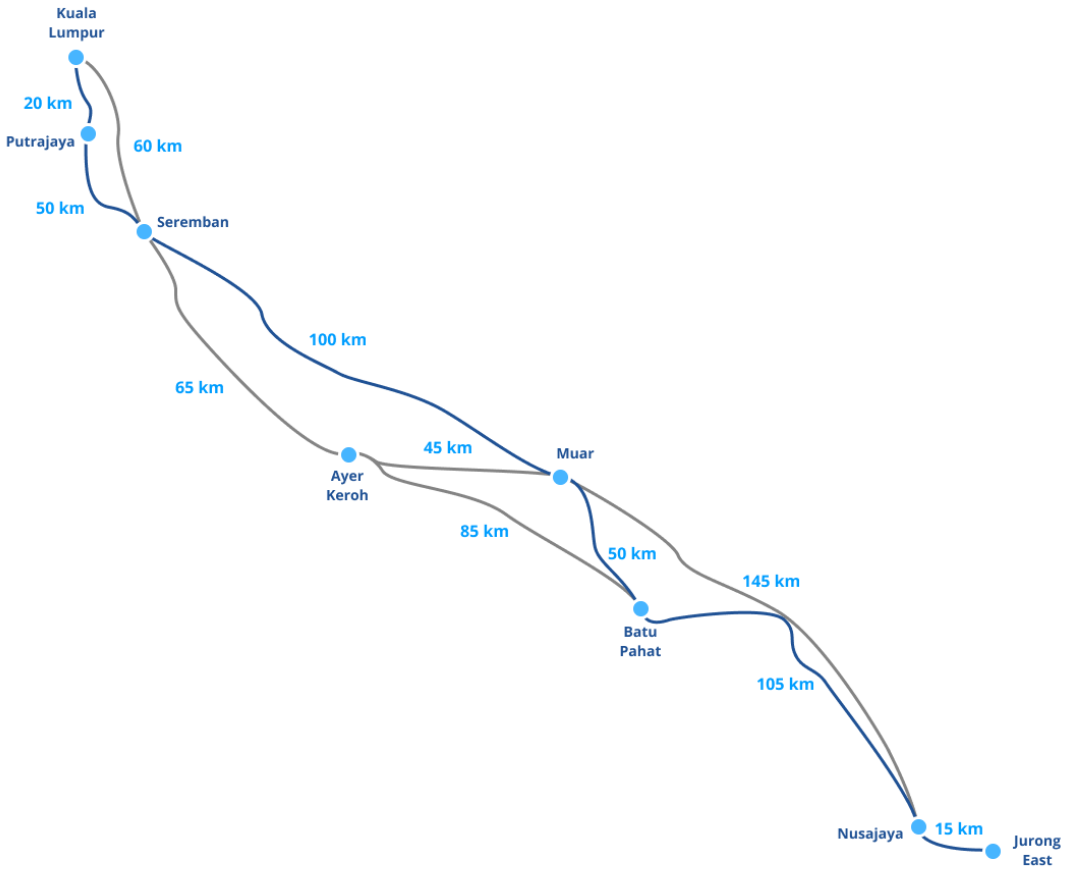

Figure 2.6: Path 4

Figure 2.6 shows the route of Path 4 for the High-Speed Rail (HSR). The route for Path 4 is highlighted in blue which connects Kuala Lumpur, Putrajaya, Seremban, Batu Pahat, Nusajaya, and Jurong East.

2.5.5 Path 5

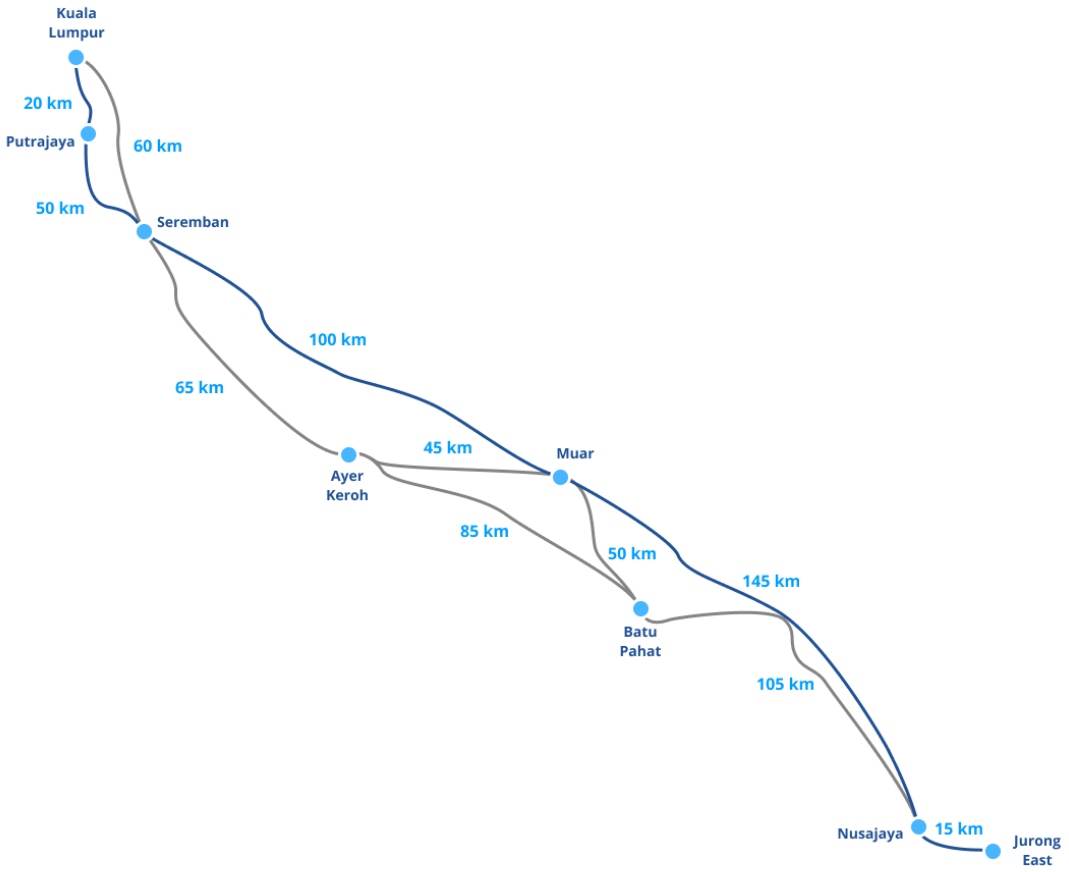

Figure 2.7: Path 5

Figure 2.7 shows the route of Path 5 for the High-Speed Rail (HSR). The route for Path 5 is highlighted in blue which connects Kuala Lumpur, Putrajaya, Seremban, Muar, Nusajaya and Jurong East.

2.5.6 Path 6

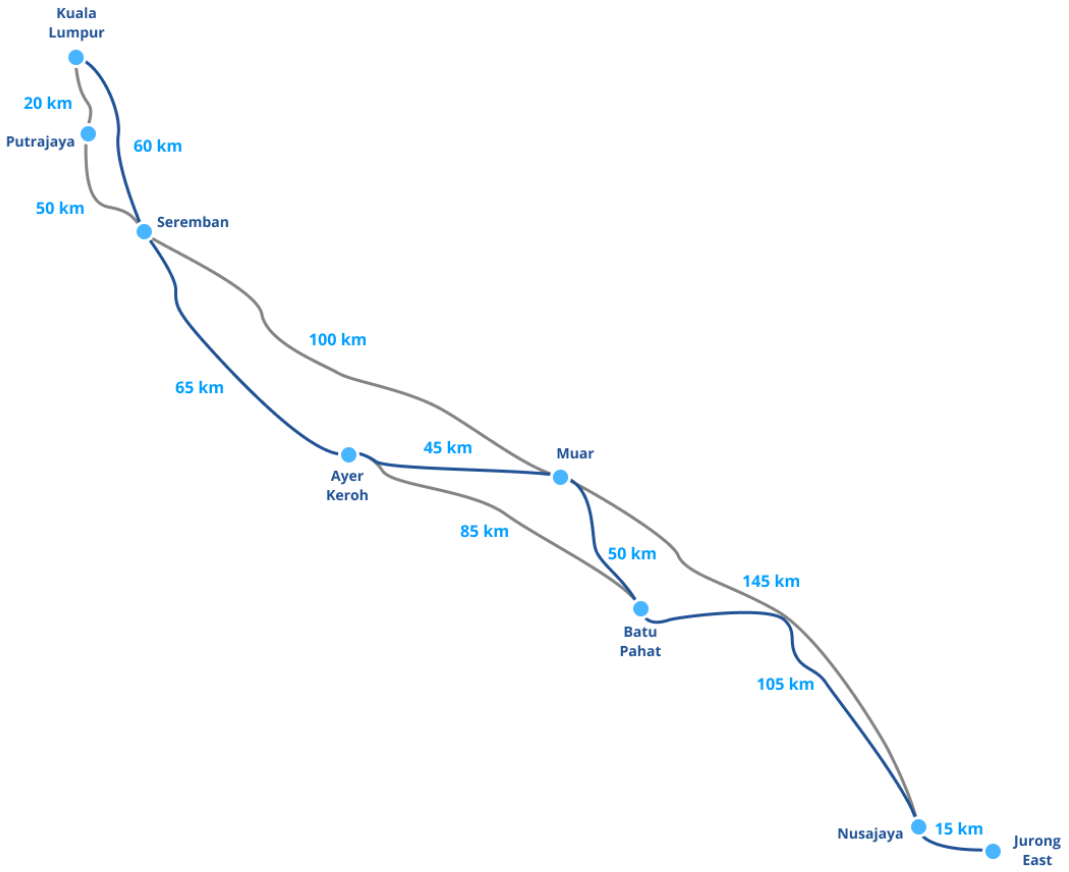

Figure 2.8: Path 6

Figure 2.8 shows the route of Path 6 for the High-Speed Rail (HSR). The route for Path 6 is highlighted in blue and connects Kuala Lumpur, Seremban, Ayer Keroh, Muar, Batu Pahat, Nusajaya and Jurong East.

2.5.7 Path 7

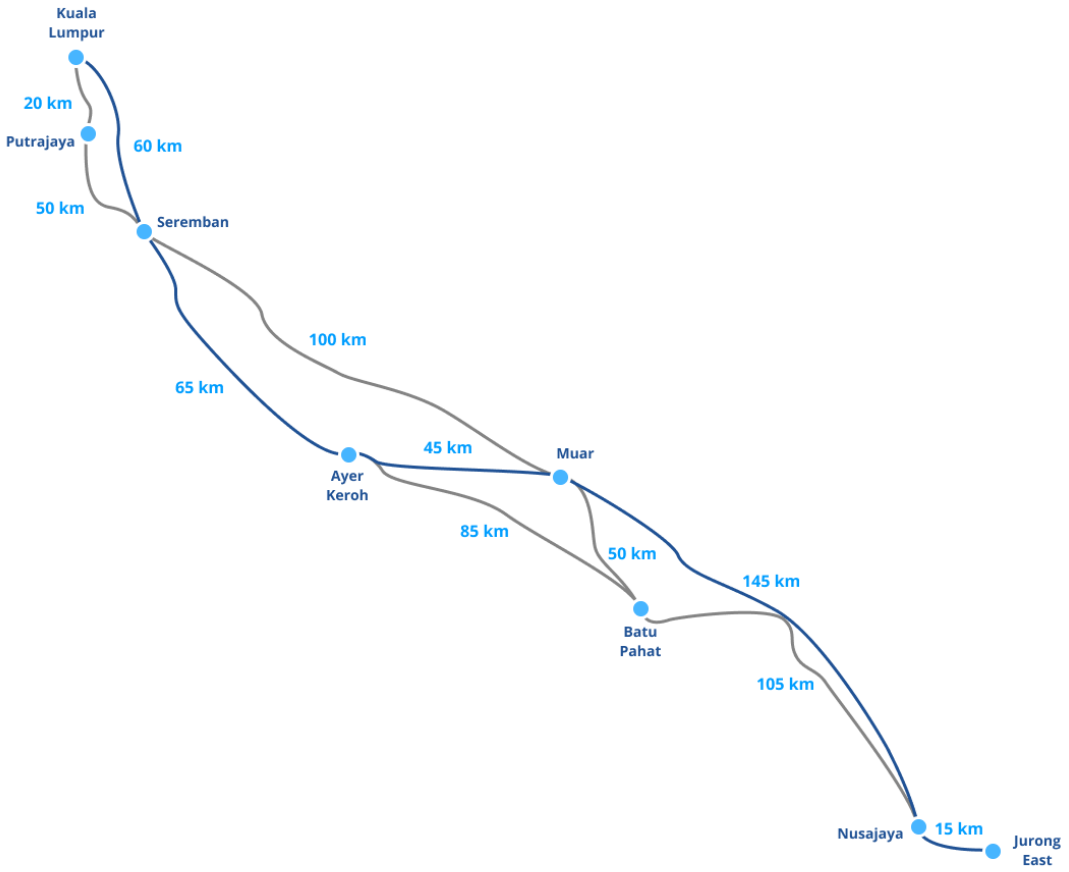

Figure 2.9: Path 7

Figure 2.9 shows the route of Path 7 for the High-Speed Rail (HSR). The route for Path 7 is highlighted in blue which connects Kuala Lumpur, Seremban, Ayer Keroh, Muar, Nusajaya and Jurong East.

2.5.8 Path 8

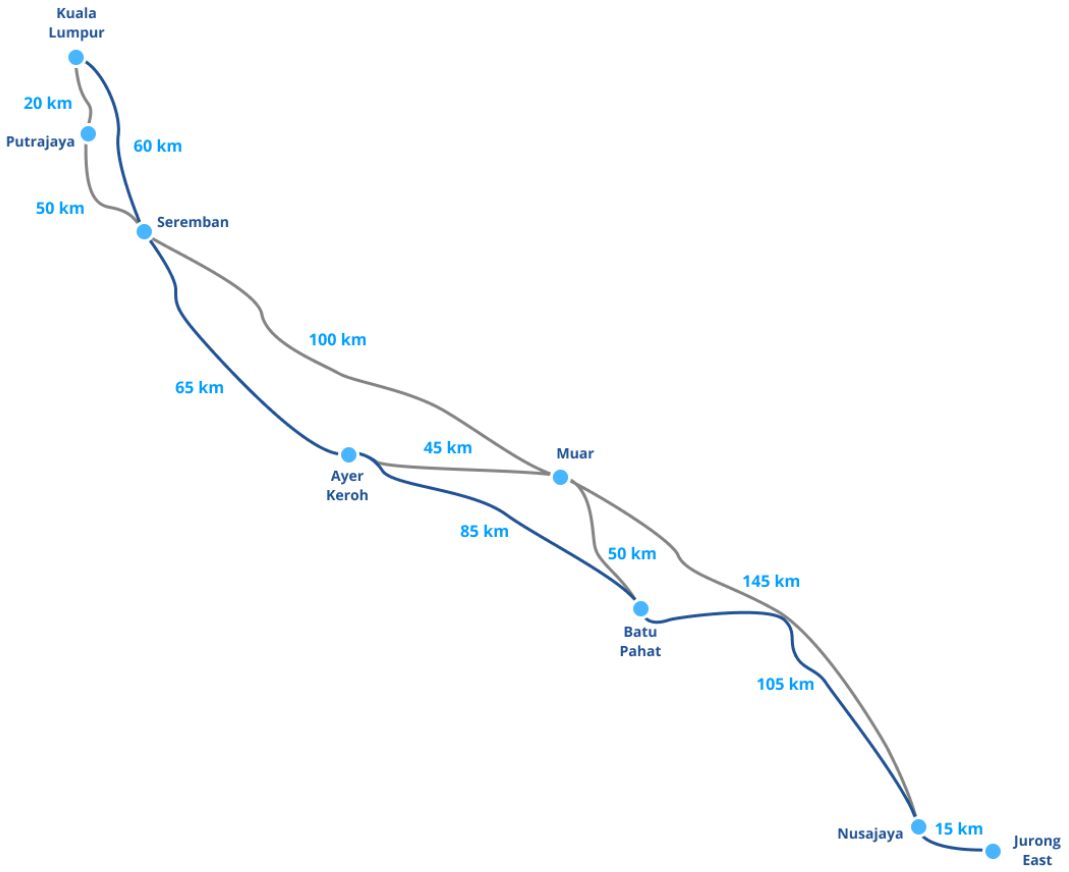

Figure 2.10: Path 8

Figure 2.10 shows the route of Path 8 for the High-Speed Rail (HSR). The route for Path 8 is highlighted in blue which connects Kuala Lumpur, Seremban, Ayer Keroh, Batu Pahat, Nusajaya and Jurong East.

2.5.9 Path 9

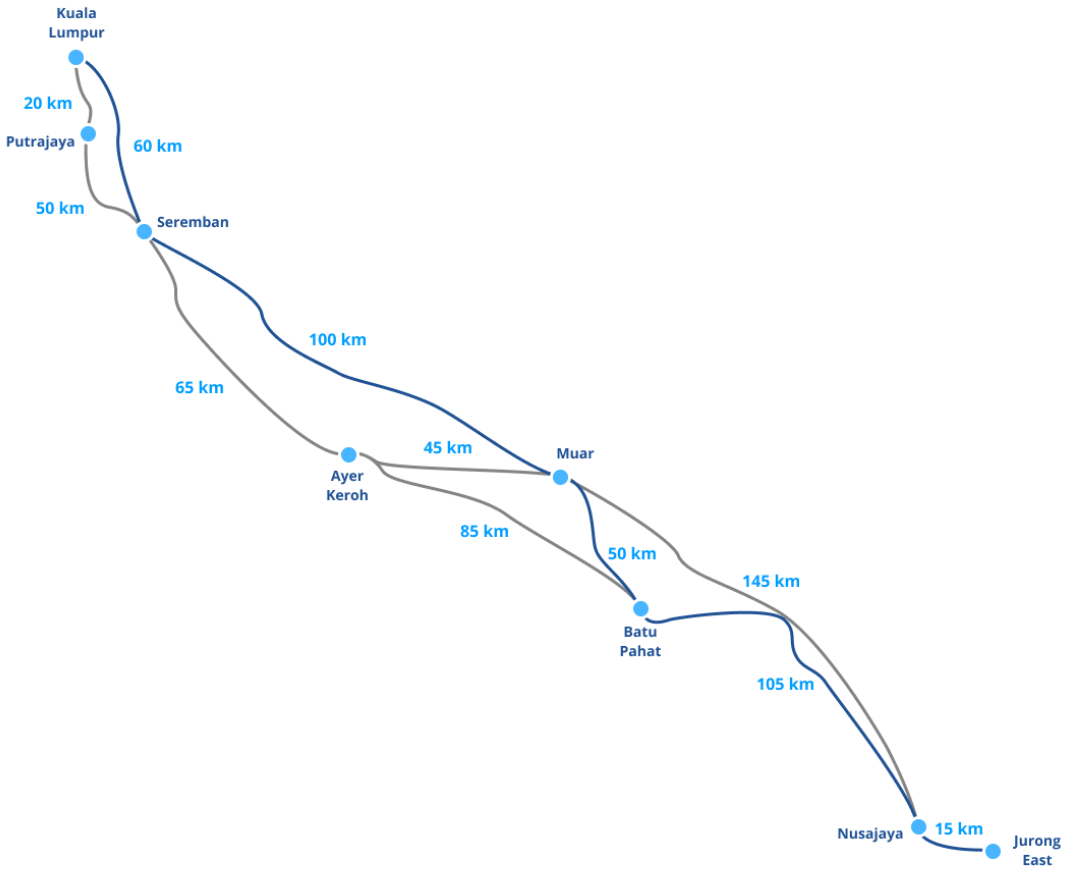

Figure 2.11: Path 9

Figure 2.11 shows the route of Path 9 for the High-Speed Rail (HSR). The route for Path 9 is highlighted in blue which connects Kuala Lumpur, Seremban, Muar, Batu Pahat, Nusajaya and Jurong East.

2.5.10 Path 10

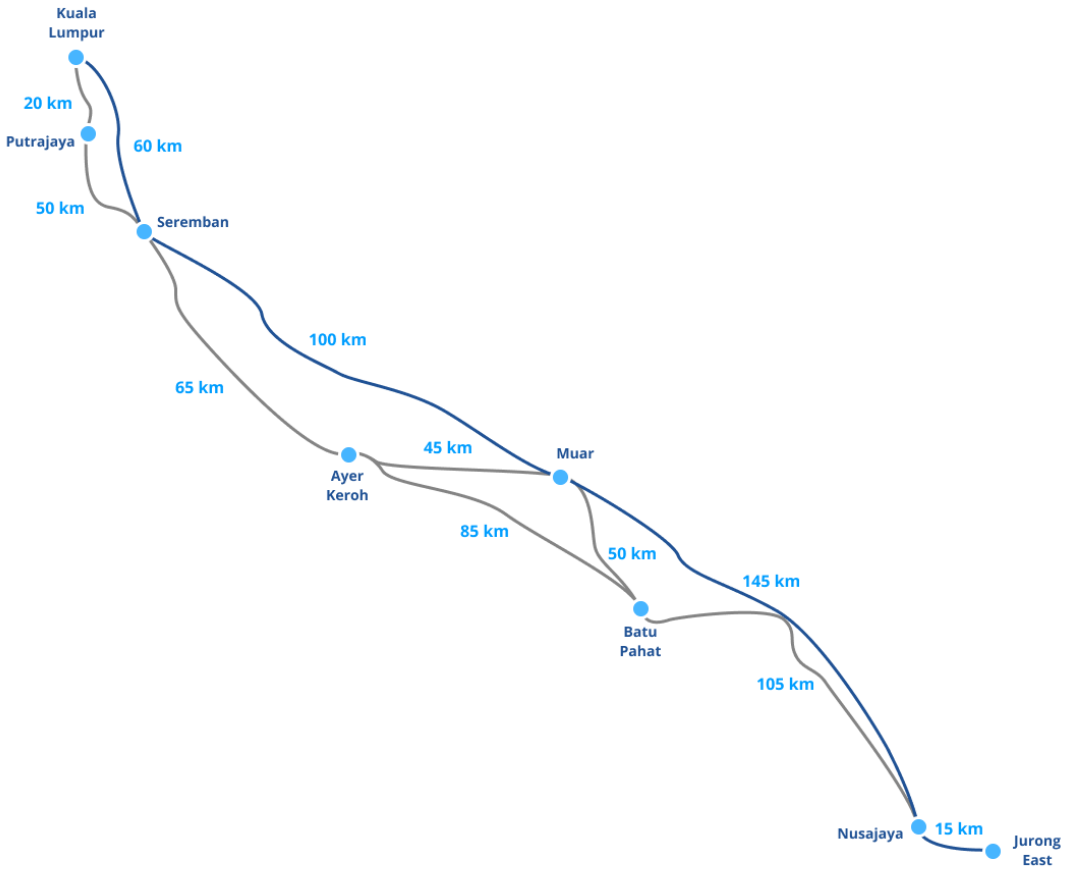

Figure 2.12: Path 10

Figure 2.12 shows the route of Path 10 for the High-Speed Rail (HSR). The route for Path 10 is highlighted in blue which connects Kuala Lumpur, Seremban, Muar, Nusajaya and Jurong East.

CHAPTER 3

PROGRAMMING AND SYSTEM

3.1 Environment Setup

Table 3.1: Platform Used

No.	Type	Software and Platform Used	Version
1	Code Editor	Visual Studio Code	1.74.2
		Eclipse	4.23
2	Programming Language	Java	jdk1.8.0_351

Table 3.1 shows the platform used during the development of the High Speed-Rail (HSR) system. Code editors are using Visual Studio Code version 1.74.2 and Eclipse version 4.23, and programming languages are using Java with jdk version 1.8.0_351.

3.2 Coding

```
1  // Discrete Structure Group Project
2  import java.text.DecimalFormat;
3
4  class Station {
5
6    static String[] stationName = {
7      "Kuala Lumpur",
8      "Putrajaya",
9      "Seremban",
10     "Ayer Keroh",
11     "Muar",
12     "Batu Pahat",
13     "Nusajaya",
14     "Jurong East",
15   };
16   private static final int NO_PARENT = -1;
17
18   // Find shortest path from KL - JE
19   private static void shortestPath(int[][] adjacencyMatrix, int startVertex) {
20     int nVertices = adjacencyMatrix[0].length;
21     int[] shortestDistances = new int[nVertices];
22     boolean[] added = new boolean[nVertices];
23
```

```
    for (int vertexIndex = 0; vertexIndex < nVertices; vertexIndex++) {
      shortestDistances[vertexIndex] = Integer.MAX_VALUE;
      added[vertexIndex] = false;
    }
    shortestDistances[startVertex] = 0;

    int[] parents = new int[nVertices];
    parents[startVertex] = NO_PARENT;

    for (int i = 1; i < nVertices; i++) {
      int nearestVertex = -1;
      int shortestDistance = Integer.MAX_VALUE;
      for (int vertexIndex = 0; vertexIndex < nVertices; vertexIndex++) {
        if (!added[vertexIndex] && shortestDistances[vertexIndex] < shortestDistance) {
          nearestVertex = vertexIndex;
          shortestDistance = shortestDistances[vertexIndex];
        }
      }

      added[nearestVertex] = true;

      for (int vertexIndex = 0; vertexIndex < nVertices; vertexIndex++) {
        int edgeDistance = adjacencyMatrix[nearestVertex][vertexIndex];

        if (edgeDistance > 0 && ((shortestDistance + edgeDistance) < shortestDistances[vertexIndex])) {
          parents[vertexIndex] = nearestVertex;
          shortestDistances[vertexIndex] = shortestDistance + edgeDistance;
        }
      }
    }
    printSolution(startVertex, shortestDistances, parents);
  }

  // Display shortest path from KL - JE
  private static void printSolution(int startVertex, int[] distances, int[] parents) {
    int vertexIndex = 7;
    double minutes = distances[vertexIndex] * 0.257142;
    double fee = distances[vertexIndex] * 0.47;
    DecimalFormat df = new DecimalFormat("###.##");
    System.out.print("\n\nThe shortest path from Kuala Lumpur to Singapore(Jurong East)");
    System.out.print("\n\nStation(from->to):\t" + stationName[startVertex] + " -> " + stationName[vertexIndex]);
    System.out.print("\nShortest route:\t\t");
    printPath(vertexIndex, parents);
    System.out.print("\nPath no:\t\t10");
    System.out.print("\nDistance:\t\t" + distances[vertexIndex] + " km");
    System.out.print("\nDuration:\t\t" + df.format(minutes) + " minutes");
    System.out.print("\nFee:\t\t\tRM" + df.format(fee));
  }

  private static void printPath(int currentVertex, int[] parents) {
    if (currentVertex == NO_PARENT) {
      return;
    }
    printPath(parents[currentVertex], parents);
    System.out.print(stationName[currentVertex]);
    if (currentVertex != 7) {
      System.out.print(" - ");
    }
  }

  static int calculateDistance(int[][] adjacencyMatrix, int[] route) {
    // Initialize distance to 0
    int distance = 0;

    // Iterate over the elements in the route array
    for (int i = 0; i < route.length - 1; i++) {
      // Add the distance between the current station and the next station to the distance
      distance += adjacencyMatrix[route[i]][route[i + 1]];
    }

    // Return the total distance
    return distance;
  }

  static void displayTable(int[][] adjacencyMatrix) {
    String[] stationName = {
      "Kuala Lumpur",
      "Putrajaya",
      "Seremban",
      "Ayer Keroh",
      "Muar",
      "Batu Pahat",
      "Nusajaya",
```

```
      "Jurong East",
    };

    int[][] routes = {
      // Route: Kuala Lumpur - Putrajaya - Seremban - Ayer Keroh - Muar - Batu Pahat - Nusajaya - Jurong East
      { 0, 1, 2, 3, 4, 5, 6, 7 },
      // Route: Kuala Lumpur - Putrajaya - Seremban - Ayer Keroh - Muar - Nusajaya - Jurong East
      { 0, 1, 2, 3, 4, 6, 7 },
      // Route: Kuala Lumpur - Putrajaya - Seremban - Ayer Keroh - Batu Pahat  - Nusajaya - Jurong East
      { 0, 1, 2, 3, 5, 6, 7 },
      // Route: Kuala Lumpur - Putrajaya - Seremban - Muar - Batu Pahat  - Nusajaya - Jurong East
      { 0, 1, 2, 4, 5, 6, 7 },
      // Route: Kuala Lumpur - Putrajaya - Seremban - Muar - Nusajaya - Jurong East
      { 0, 1, 2, 4, 6, 7 },
      // Route: Kuala Lumpur - Seremban - Ayer Keroh - Muar - Batu Pahat - Nusajaya - Jurong East
      { 0, 2, 3, 4, 5, 6, 7 },
      // Route: Kuala Lumpur - Seremban - Ayer Keroh - Muar - Nusajaya - Jurong East
      { 0, 2, 3, 4, 6, 7 },
      // Route: Kuala Lumpur - Seremban - Ayer Keroh - Batu Pahat - Nusajaya - Jurong East
      { 0, 2, 3, 5, 6, 7 },
      // Route: Kuala Lumpur - Seremban - Muar - Batu Pahat - Nusajaya - Jurong East
      { 0, 2, 4, 5, 6, 7 },
      // Route: Kuala Lumpur - Seremban - Muar - Nusajaya - Jurong East
      { 0, 2, 4, 6, 7 },
    };

    // Display each path and its route, distance, duration and fee
    System.out.println(
      "\nPath No.\t\tRoute\t\t\t\t\t\t\t\t\t\tTotal Distance (km)\tDuration (minutes)\t   Fee (RM)"
    );
    System.out.println(
      "-------\t\t\t-----\t\t\t\t\t\t\t\t\t\t-----------------\t-----------------\t   -------"
    );

    int counter = 1;
    for (int[] route : routes) {
      int distance = calculateDistance(adjacencyMatrix, route);
      double duration = distance * 0.257142;
      double fee = distance * 0.47;

      String routeString = "";
      for (int i : route) {
        routeString += stationName[i] + " - ";
      }
      routeString = routeString.substring(0, routeString.length() - 3); // remove the last " - "

      System.out.printf("%-11d%-99s%-22d%-24.2f%-15.2f\n", counter, routeString, distance, duration, fee);
      counter++;
    }
  }

  public static void main(String[] args) {
    int[][] adjacencyMatrix = {
      { 0, 20, 60, 0, 0, 0, 0, 0 }, // Stations location in matrix
      { 20, 0, 50, 0, 0, 0, 0, 0 },
      { 60, 50, 0, 65, 100, 0, 0, 0 },
      { 0, 0, 65, 0, 45, 85, 0, 0 },
      { 0, 0, 100, 45, 0, 50, 145, 0 },
      { 0, 0, 0, 85, 50, 0, 105, 0 },
      { 0, 0, 0, 0, 145, 105, 0, 15 },
      { 0, 0, 0, 0, 0, 0, 15, 0 },
    };
    System.out.print("\nSystem to calculate the shortest path from Kuala Lumpur to Singapore(Jurong East)\n\n");

    displayTable(adjacencyMatrix);
    shortestPath(adjacencyMatrix, 0);
  }
}
```

Figure 3.1: Coding

3.3 Output

```
# adibnawfal in DESKTOP-OUA5GO7  D: 〉Projects 〉Java
➜  javac Station.java
# adibnawfal in DESKTOP-OUA5GO7  D: 〉Projects 〉Java
➜  java Station

System to calculate the shortest path from Kuala Lumpur to Singapore(Jurong East)


Path No.        Route                                                                   Total Distance (km)     Duration (minutes)      Fee (RM)
--------        -----                                                                   -------------------     ------------------      --------
1               Kuala Lumpur – Putrajaya – Seremban – Ayer Keroh – Muar – Batu Pahat – Nusajaya – Jurong East      350                     90.00                   164.50
2               Kuala Lumpur – Putrajaya – Seremban – Ayer Keroh – Muar – Nusajaya – Jurong East                   340                     87.43                   159.80
3               Kuala Lumpur – Putrajaya – Seremban – Ayer Keroh – Batu Pahat – Nusajaya – Jurong East             340                     87.43                   159.80
4               Kuala Lumpur – Putrajaya – Seremban – Muar – Batu Pahat – Nusajaya – Jurong East                   340                     87.43                   159.80
5               Kuala Lumpur – Putrajaya – Seremban – Muar – Nusajaya – Jurong East                                330                     84.86                   155.10
6               Kuala Lumpur – Seremban – Ayer Keroh – Muar – Batu Pahat – Nusajaya – Jurong East                  340                     87.43                   159.80
7               Kuala Lumpur – Seremban – Ayer Keroh – Muar – Nusajaya – Jurong East                               330                     84.86                   155.10
8               Kuala Lumpur – Seremban – Ayer Keroh – Batu Pahat – Nusajaya – Jurong East                         330                     84.86                   155.10
9               Kuala Lumpur – Seremban – Muar – Batu Pahat – Nusajaya – Jurong East                               330                     84.86                   155.10
10              Kuala Lumpur – Seremban – Muar – Nusajaya – Jurong East                                            320                     82.29                   150.40


The shortest path from Kuala Lumpur to Singapore(Jurong East)

Station(from->to):      Kuala Lumpur -> Jurong East
Shortest route:         Kuala Lumpur – Seremban – Muar – Nusajaya – Jurong East
Path no:                10
Distance:               320 km
Duration:               82.29 minutes
Fee:                    RM150.4
```

Figure 3.2: Output

CHAPTER 4

ANALYSIS OF THE RESULT

4.1 Result

Based on the output for the High-Speed Rail (HSR) system, Path 10 is the shortest path linking Kuala Lumpur to Singapore. Path 10 has the shortest route compared to other paths that connect Kuala Lumpur, Seremban, Muar, Nusajaya, and Jurong East. Based on the result, Path 10 has a total of 320 km in distance, 82.29 of duration in minutes and a total of RM150.40 for the fare. Path 10 is not only the shortest path but also has the shortest duration and the least expensive fare compared to other paths.

From the research done, Euler paths and circuits are not suitable for the Kuala Lumpur-Singapore High Speed Rail (KL-SG HSR) project because they are concepts from graph theory that are used to analyze the structure of graphs and the relationships between the vertices (or nodes) and edges in a graph. Additionally, Hamilton paths and circuits are not appropriate for this project because they visit each vertex in a graph exactly once. A Hamilton circuit is a Hamilton path that is also a cycle, meaning it starts and ends at the same vertex. They are not applicable to other types of systems or projects.

The KL-SG HSR project involves a transportation system with multiple stations connected by rail tracks, but it is not represented as a graph. Instead, Dijkstra's algorithm is being used to find the shortest path between two stations on the KL-SG HSR. It is not possible to use Hamilton paths and circuits or Euler paths and circuits for this.

Overall, Hamilton paths and circuits are useful for situations in which it is necessary to visit every vertex or edge in a graph exactly once, and the order in which they are visited is important. Meanwhile, Euler paths and circuits are used to analyze the structure of a graph and determine whether it is possible to traverse the graph such that every edge is used exactly once. They are not relevant to the KL-SG HSR project, which involves a transportation system with stations and rail tracks rather than a graph, and the project's main target is to find the shortest path from Kuala Lumpur to Singapore.

4.2 Conclusion

The use of Dijkstra's algorithm and an adjacency matrix were key in determining the optimal route for the Kuala Lumpur-Singapore High Speed Rail. The algorithm was used to find the shortest path between Kuala Lumpur and Singapore, while the adjacency matrix was used to represent the relationships between the various stops along the route.

In conclusion, the use of programming, discrete mathematics and algorithms, specifically the Dijkstra's Algorithm, were crucial in determining the optimal route for the Kuala Lumpur-Singapore High Speed Rail. By utilizing graph theory and creating a mathematical model, various paths were analysed and compared using programming techniques. This led to the identification of the shortest and most cost-effective route, emphasizing the practical value of programming, discrete mathematics and algorithms in optimizing complex systems in real-life situations. The successful application of these tools highlights the importance of incorporating programming, mathematical concepts and algorithms in the analysis and design of transportation systems.

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APPENDICES

Minute of Meeting (23 December 2022, 9.00 PM)