PROJECT REPORT : ECEN 654

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PROGRAMMING ASSIGNMENT 1:

PERFORM KERNINGHAN-LIN 5 WAY PARTITIONING AND 3-2-1 WAY PARTITIONING USING THE GIVEN NETLIST.

**Implementation:**

We are given a netlist consisting of 100 nets and the goal is to partition them using KL algorithm in following ways:

* 5way even partitioning
* 3way 3-2-1 partitioning

In 5 way even partitioning the number of nodes in the netlist is divided by 5 to get 5 set of nodes of equal size. In 3-2-1 way partition we divide the number of nodes in the netlist in the ratio of 3:2:1 following which we perform 2 way kerninghan Lin algorithm.

Two scripts have been used by the name of fiveway.m and kerninghan\_lin\_3\_2\_1.m and an input netlist in the form of net.txt has been provided.

1. **Fiveway.m**

In this script we use 2 functions graph\_list and twpp.

Graph\_list transforms the netlist into a graph and at first the text file is parse and the nodes for each are stored in an array. Following it we create a graph using the graph function in matlab and to avoid repetition of edges we use the unique function.

The twpp function implements the Kerninghan Lin Algorithm for the two way partition. In this case we calculate ‘D’ and gain for each nodes and the maximum gain is evaluated using the ‘toeplitz’ function. Finally with the setdiff function we remove the elements to be swapped from the individual partitions and we add using the ‘swapnode’ array to merge the elements that are to be swapped to their respective partitions.

For the remaining script we call the Graph\_List and then divide the script in five parts. Then we select any two partitions at random and evaluate the optimum solution using the twpp function. The cost function and the partitions are then updated and and for every iteration we find the cost function decreases and is a linear function of iterations. Since KL algorithm is a heuristic based algorithm it is an NP complete problem and thus optimal solution can be achieved only at infinite number of iterations.

1. **Kerninghan\_Lin.m**

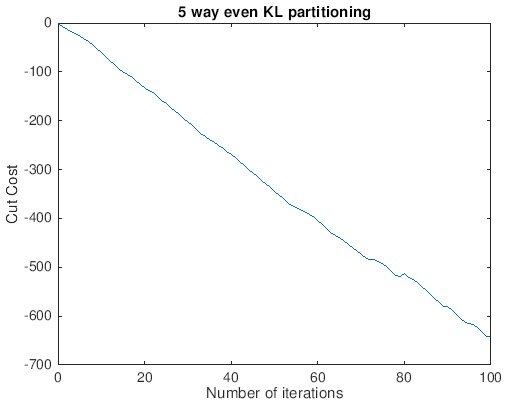
In this script we use 2 functions graph\_list and twpp.

Graph\_list transforms the netlist into a graph and at first the text file is parse and the nodes for each are stored in an array. Following it we create a graph using the graph function in matlab and to avoid repetition of edges we use the unique function.

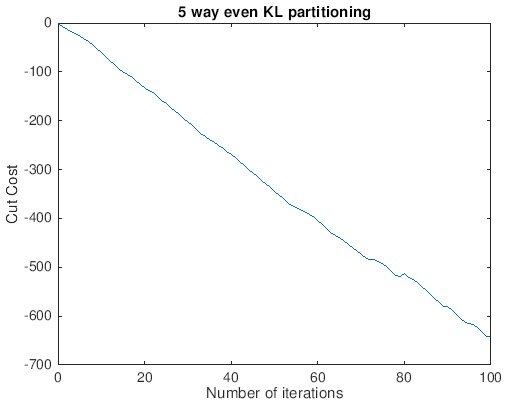
The twpp function implements the Kerninghan Lin Algorithm for the two way partition. In this case we calculate ‘D’ and gain for each nodes and the maximum gain is evaluated using the ‘toeplitz’ function. Finally with the setdiff function we remove the elements to be swapped from the individual partitions and we add using the ‘swapnode’ array to merge the elements that are to be swapped to their respective partitions.

For the remaining script we call the Graph\_List and then divide the script in the closet ratioin integers and then assign them in individual partitions. For the lesser sized partitions we fill them with zeros. Then we select any two partitions at random and evaluate the optimum solution using the twpp function. The cost function and partitions are then updated and and for every iteration we find the cost function decreases and is a linear function of iterations. Since KL algorithm is a heuristic based algorithm it is an NP complete problem and thus optimal solution can be achieved only at infinite number of iterations.

1. Output curve for cost vs interation the KL 3-2-1 way partitioning:



1. Output curve of Cut Cost with respect to iteration for the KL 5 way even partitioning:



Sample Output for the 5 way KL partitioning:

--------------------------------------------------

Initial partition

--------------------------------------------------

1 2 3 4

5 6 7 8

9 10 11 12

13 14 15 16

17 18 19 20

--------------------------------------------------

Partition after Iteration Number 1 :

--------------------------------------------------

1 2 3 4

6 7 8 20

9 10 11 12

13 14 15 16

5 17 18 19

--------------------------------------------------

Partition after Iteration Number 2 :

--------------------------------------------------

1 2 4 13

6 7 8 20

9 10 11 12

3 14 15 16

5 17 18 19

--------------------------------------------------

Partition after Iteration Number 3 :

--------------------------------------------------

2 4 13 17

6 7 8 20

9 10 11 12

3 14 15 16

1 5 18 19

--------------------------------------------------

Partition after Iteration Number 4 :

--------------------------------------------------

1 4 13 17

6 7 8 20

9 10 11 12

3 14 15 16

2 5 18 19

--------------------------------------------------

Partition after Iteration Number 5 :

--------------------------------------------------

1 4 13 17

6 7 8 20

2 10 11 12

3 14 15 16

5 9 18 19

--------------------------------------------------

Partition after Iteration Number 6 :

--------------------------------------------------

1 4 13 17

5 7 8 20

2 10 11 12

3 14 15 16

6 9 18 19

--------------------------------------------------

Partition after Iteration Number 7 :

--------------------------------------------------

1 4 13 17

5 8 12 20

2 7 10 11

3 14 15 16

6 9 18 19

--------------------------------------------------

Partition after Iteration Number 8 :

--------------------------------------------------

1 3 4 13

5 8 12 20

2 7 10 11

14 15 16 17

6 9 18 19

--------------------------------------------------

Partition after Iteration Number 9 :

--------------------------------------------------

1 3 4 13

7 8 12 20

2 5 10 11

14 15 16 17

6 9 18 19

--------------------------------------------------

Partition after Iteration Number 10 :

--------------------------------------------------

1 3 4 13

6 8 12 20

2 5 10 11

14 15 16 17

7 9 18 19

--------------------------------------------------

Partition after Iteration Number 11 :

--------------------------------------------------

3 4 7 13

6 8 12 20

2 5 10 11

14 15 16 17

1 9 18 19

--------------------------------------------------

Partition after Iteration Number 12 :

--------------------------------------------------

3 4 7 13

6 8 12 20

2 5 10 11

1 15 16 17

9 14 18 19

--------------------------------------------------

Partition after Iteration Number 13 :

--------------------------------------------------

3 4 7 13

1 8 12 20

2 5 10 11

6 15 16 17

9 14 18 19

--------------------------------------------------

Partition after Iteration Number 14 :

--------------------------------------------------

2 4 7 13

1 8 12 20

3 5 10 11

6 15 16 17

9 14 18 19

--------------------------------------------------

Partition after Iteration Number 15 :

--------------------------------------------------

2 4 7 13

3 8 12 20

1 5 10 11

6 15 16 17

9 14 18 19

--------------------------------------------------

Partition after Iteration Number 16 :

--------------------------------------------------

3 4 7 13

2 8 12 20

1 5 10 11

6 15 16 17

9 14 18 19

--------------------------------------------------

Partition after Iteration Number 17 :

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3 4 7 13

8 12 19 20

1 5 10 11

6 15 16 17

2 9 14 18

--------------------------------------------------

Partition after Iteration Number 18 :

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3 4 7 13

8 12 19 20

1 5 10 11

2 15 16 17

6 9 14 18

--------------------------------------------------

Partition after Iteration Number 19 :

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4 6 7 13

8 12 19 20

1 5 10 11

2 15 16 17

3 9 14 18

--------------------------------------------------

Partition after Iteration Number 20 :

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4 6 7 13

2 12 19 20

1 5 10 11

8 15 16 17

3 9 14 18

--------------------------------------------------

Partition after Iteration Number 21 :

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2 6 7 13

4 12 19 20

1 5 10 11

8 15 16 17

3 9 14 18

--------------------------------------------------

Partition after Iteration Number 22 :

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2 6 7 13

4 12 19 20

5 9 10 11

8 15 16 17

1 3 14 18

--------------------------------------------------

Partition after Iteration Number 23 :

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3 6 7 13

4 12 19 20

5 9 10 11

8 15 16 17

1 2 14 18

--------------------------------------------------

Partition after Iteration Number 24 :

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3 6 7 13

5 9 10 20

4 11 12 19

8 15 16 17

1 2 14 18

--------------------------------------------------

Partition after Iteration Number 25 :

--------------------------------------------------

6 7 8 13

5 9 10 20

4 11 12 19

3 15 16 17

1 2 14 18

--------------------------------------------------

Partition after Iteration Number 26 :

--------------------------------------------------

6 7 8 13

3 5 9 10

4 11 12 19

15 16 17 20

1 2 14 18

--------------------------------------------------

Partition after Iteration Number 27 :

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6 7 8 13

5 9 10 17

4 11 12 19

3 15 16 20

1 2 14 18

--------------------------------------------------

Partition after Iteration Number 28 :

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6 7 8 13

5 9 10 17

3 11 12 19

4 15 16 20

1 2 14 18

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Partition after Iteration Number 29 :

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4 6 7 8

5 9 10 17

3 11 12 19

13 15 16 20

1 2 14 18

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Partition after Iteration Number 30 :

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1 6 7 8

5 9 10 17

3 11 12 19

13 15 16 20

2 4 14 18

--------------------------------------------------

Partition after Iteration Number 31 :

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1 6 7 8

9 10 13 17

3 11 12 19

5 15 16 20

2 4 14 18

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Partition after Iteration Number 32 :

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3 6 7 8

9 10 13 17

1 11 12 19

5 15 16 20

2 4 14 18

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Partition after Iteration Number 33 :

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3 6 7 8

9 10 13 17

5 11 12 19

1 15 16 20

2 4 14 18

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Partition after Iteration Number 34 :

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2 6 7 8

9 10 13 17

5 11 12 19

1 15 16 20

3 4 14 18

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Partition after Iteration Number 35 :

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2 6 7 8

9 10 13 17

1 5 11 12

15 16 19 20

3 4 14 18

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Partition after Iteration Number 36 :

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1 6 7 8

9 10 13 17

2 5 11 12

15 16 19 20

3 4 14 18

--------------------------------------------------

Partition after Iteration Number 37 :

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1 6 7 8

9 10 13 17

2 5 11 12

3 16 19 20

4 14 15 18

--------------------------------------------------

Partition after Iteration Number 38 :

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1 6 7 8

10 13 14 17

2 5 11 12

3 16 19 20

4 9 15 18

--------------------------------------------------

Partition after Iteration Number 39 :

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1 4 7 8

10 13 14 17

2 5 11 12

3 16 19 20

6 9 15 18

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Partition after Iteration Number 40 :

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1 4 7 8

10 13 14 17

3 5 11 12

2 16 19 20

6 9 15 18

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Partition after Iteration Number 41 :

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3 4 5 8

10 13 14 17

1 7 11 12

2 16 19 20

6 9 15 18

--------------------------------------------------

Partition after Iteration Number 42 :

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3 4 5 8

10 13 14 17

1 7 11 12

6 16 19 20

2 9 15 18

--------------------------------------------------

Partition after Iteration Number 43 :

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3 4 5 8

10 13 14 17

1 7 11 12

2 16 19 20

6 9 15 18

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Partition after Iteration Number 44 :

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3 4 5 8

1 13 14 17

7 10 11 12

2 16 19 20

6 9 15 18

--------------------------------------------------

Partition after Iteration Number 45 :

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3 4 5 8

1 6 13 17

7 10 11 12

2 16 19 20

9 14 15 18

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Partition after Iteration Number 46 :

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4 5 8 9

1 6 13 17

7 10 11 12

2 16 19 20

3 14 15 18

--------------------------------------------------

Partition after Iteration Number 47 :

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4 5 8 9

6 12 13 17

1 7 10 11

2 16 19 20

3 14 15 18

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Partition after Iteration Number 48 :

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4 5 8 9

3 12 13 17

1 7 10 11

2 16 19 20

6 14 15 18

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Partition after Iteration Number 49 :

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4 5 8 9

1 12 13 17

3 7 10 11

2 16 19 20

6 14 15 18

--------------------------------------------------

Partition after Iteration Number 50 :

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4 5 8 9

1 12 13 17

3 6 7 10

2 16 19 20

11 14 15 18

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Partition after Iteration Number 51 :

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4 5 8 9

1 12 13 17

6 7 10 11

2 16 19 20

3 14 15 18

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Partition after Iteration Number 52 :

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4 5 8 9

1 12 13 17

2 7 10 11

6 16 19 20

3 14 15 18

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Partition after Iteration Number 53 :

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4 5 8 9

1 12 13 17

7 10 11 14

6 16 19 20

2 3 15 18

--------------------------------------------------

Partition after Iteration Number 54 :

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4 5 8 9

7 12 13 17

1 10 11 14

6 16 19 20

2 3 15 18

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Partition after Iteration Number 55 :

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4 5 8 9

7 12 13 17

1 10 11 14

2 6 16 19

3 15 18 20

--------------------------------------------------

Partition after Iteration Number 56 :

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5 8 9 11

7 12 13 17

1 4 10 14

2 6 16 19

3 15 18 20

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Partition after Iteration Number 57 :

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2 8 9 11

7 12 13 17

1 4 10 14

5 6 16 19

3 15 18 20

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Partition after Iteration Number 58 :

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2 8 9 11

12 13 17 19

1 4 10 14

5 6 7 16

3 15 18 20

--------------------------------------------------

Partition after Iteration Number 59 :

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2 8 9 11

12 13 17 19

1 3 10 14

5 6 7 16

4 15 18 20

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Partition after Iteration Number 60 :

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2 8 9 11

1 13 17 19

3 10 12 14

5 6 7 16

4 15 18 20

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Partition after Iteration Number 61 :

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2 8 9 11

1 13 17 19

4 10 12 14

5 6 7 16

3 15 18 20

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Partition after Iteration Number 62 :

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2 8 9 11

1 13 17 19

3 10 12 14

5 6 7 16

4 15 18 20

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Partition after Iteration Number 63 :

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2 8 9 11

1 5 17 19

3 10 12 14

6 7 13 16

4 15 18 20

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Partition after Iteration Number 64 :

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2 8 9 11

1 5 17 19

3 10 12 14

4 7 13 16

6 15 18 20

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Partition after Iteration Number 65 :

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3 8 9 11

1 5 17 19

2 10 12 14

4 7 13 16

6 15 18 20

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Partition after Iteration Number 66 :

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3 8 9 11

1 5 17 19

4 10 12 14

2 7 13 16

6 15 18 20

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Partition after Iteration Number 67 :

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3 8 9 11

4 5 17 19

1 10 12 14

2 7 13 16

6 15 18 20

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Partition after Iteration Number 68 :

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3 8 9 11

4 17 18 19

1 10 12 14

2 7 13 16

5 6 15 20

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Partition after Iteration Number 69 :

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3 8 9 11

1 4 18 19

10 12 14 17

2 7 13 16

5 6 15 20

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Partition after Iteration Number 70 :

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3 8 9 11

4 10 18 19

1 12 14 17

2 7 13 16

5 6 15 20

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Partition after Iteration Number 71 :

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3 8 9 11

4 10 18 19

1 12 14 17

5 7 13 16

2 6 15 20

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Partition after Iteration Number 72 :

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1 8 9 11

4 10 18 19

3 12 14 17

5 7 13 16

2 6 15 20

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Partition after Iteration Number 73 :

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1 3 8 9

4 10 18 19

11 12 14 17

5 7 13 16

2 6 15 20

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Partition after Iteration Number 74 :

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1 3 8 9

4 10 18 19

12 13 14 17

5 7 11 16

2 6 15 20

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Partition after Iteration Number 75 :

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1 2 8 9

4 10 18 19

12 13 14 17

5 7 11 16

3 6 15 20

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Partition after Iteration Number 76 :

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1 2 8 9

4 5 18 19

12 13 14 17

7 10 11 16

3 6 15 20

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Partition after Iteration Number 77 :

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1 2 8 9

4 5 18 19

7 10 12 14

11 13 16 17

3 6 15 20

--------------------------------------------------

Partition after Iteration Number 78 :

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1 2 8 9

4 5 18 19

7 10 12 14

6 13 16 17

3 11 15 20

--------------------------------------------------

Partition after Iteration Number 79 :

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1 2 8 9

4 5 18 19

7 10 12 14

11 13 16 17

3 6 15 20

--------------------------------------------------

Partition after Iteration Number 80 :

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1 2 8 9

4 5 18 19

3 7 12 14

11 13 16 17

6 10 15 20

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Partition after Iteration Number 81 :

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2 5 8 9

1 4 18 19

3 7 12 14

11 13 16 17

6 10 15 20

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Partition after Iteration Number 82 :

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2 5 8 9

4 6 18 19

3 7 12 14

11 13 16 17

1 10 15 20

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Partition after Iteration Number 83 :

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2 5 8 9

3 6 18 19

4 7 12 14

11 13 16 17

1 10 15 20

--------------------------------------------------

Partition after Iteration Number 84 :

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2 5 8 9

3 6 18 19

11 12 14 16

4 7 13 17

1 10 15 20

--------------------------------------------------

Partition after Iteration Number 85 :

--------------------------------------------------

2 5 8 9

6 11 18 19

3 12 14 16

4 7 13 17

1 10 15 20

--------------------------------------------------

Partition after Iteration Number 86 :

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2 5 8 9

6 11 18 19

3 12 14 16

1 7 13 17

4 10 15 20

--------------------------------------------------

Partition after Iteration Number 87 :

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4 5 8 9

6 11 18 19

3 12 14 16

1 7 13 17

2 10 15 20

--------------------------------------------------

Partition after Iteration Number 88 :

--------------------------------------------------

4 5 8 9

11 15 18 19

3 12 14 16

1 7 13 17

2 6 10 20

--------------------------------------------------

Partition after Iteration Number 89 :

--------------------------------------------------

3 5 8 9

11 15 18 19

4 12 14 16

1 7 13 17

2 6 10 20

--------------------------------------------------

Partition after Iteration Number 90 :

--------------------------------------------------

1 5 8 9

11 15 18 19

4 12 14 16

3 7 13 17

2 6 10 20

--------------------------------------------------

Partition after Iteration Number 91 :

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4 5 8 9

11 15 18 19

1 12 14 16

3 7 13 17

2 6 10 20

--------------------------------------------------

Partition after Iteration Number 92 :

--------------------------------------------------

1 4 8 9

11 15 18 19

5 12 14 16

3 7 13 17

2 6 10 20

--------------------------------------------------

Partition after Iteration Number 93 :

--------------------------------------------------

1 4 8 9

11 15 18 19

2 12 14 16

3 7 13 17

5 6 10 20

--------------------------------------------------

Partition after Iteration Number 94 :

--------------------------------------------------

1 4 8 9

5 15 18 19

2 12 14 16

3 7 13 17

6 10 11 20

--------------------------------------------------

Partition after Iteration Number 95 :

--------------------------------------------------

4 5 8 9

1 15 18 19

2 12 14 16

3 7 13 17

6 10 11 20

--------------------------------------------------

Partition after Iteration Number 96 :

--------------------------------------------------

4 5 8 9

1 15 18 19

2 12 14 16

3 7 13 17

6 10 11 20

--------------------------------------------------

Partition after Iteration Number 97 :

--------------------------------------------------

3 5 8 9

1 15 18 19

2 12 14 16

4 7 13 17

6 10 11 20

--------------------------------------------------

Partition after Iteration Number 98 :

--------------------------------------------------

3 5 8 9

1 15 18 19

2 12 14 16

4 6 7 17

10 11 13 20

--------------------------------------------------

Partition after Iteration Number 99 :

--------------------------------------------------

3 5 8 9

1 15 18 19

10 12 14 16

4 6 7 17

2 11 13 20

--------------------------------------------------

Partition after Iteration Number 100 :

--------------------------------------------------

3 5 8 9

1 15 18 19

6 12 14 16

4 7 10 17

2 11 13 20

--------------------------------------------------

Final Partition List :

--------------------------------------------------

3 5 8 9

1 15 18 19

6 12 14 16

4 7 10 17

2 11 13 20

Output for the 3-2-1 way KL partitioning:

20

1 2 3 4 5 6 7 8 9 10

11 12 13 14 15 16 0 0 0 0

17 18 19 20 0 0 0 0 0 0

--------------------------------------------------

Initial partition

--------------------------------------------------

1 2 3 4 5 6 7 8 9 10

11 12 13 14 15 16

17 18 19 20

--------------------------------------------------

Partition after Iteration Number 1 :

--------------------------------------------------

1 2 3 5 6 7 8 9 10 11

4 12 13 14 15 16

17 18 19 20

--------------------------------------------------

Partition after Iteration Number 2 :

--------------------------------------------------

1 2 4 5 6 7 8 9 10 11

3 12 13 14 15 16

17 18 19 20

--------------------------------------------------

Partition after Iteration Number 3 :

--------------------------------------------------

1 2 4 5 6 7 8 9 10 11

3 13 14 15 16 17

12 18 19 20

--------------------------------------------------

Partition after Iteration Number 4 :

--------------------------------------------------

1 2 4 5 6 7 8 9 10 11

12 13 14 15 16 17

3 18 19 20

--------------------------------------------------

Partition after Iteration Number 5 :

--------------------------------------------------

2 4 5 6 7 8 9 10 11 20

12 13 14 15 16 17

1 3 18 19

--------------------------------------------------

Partition after Iteration Number 6 :

--------------------------------------------------

2 4 5 6 7 8 9 10 11 20

1 12 14 15 16 17

3 13 18 19

--------------------------------------------------

Partition after Iteration Number 7 :

--------------------------------------------------

1 4 5 6 7 8 9 10 11 20

2 12 14 15 16 17

3 13 18 19

--------------------------------------------------

Partition after Iteration Number 8 :

--------------------------------------------------

2 4 5 6 7 8 9 10 11 20

1 12 14 15 16 17

3 13 18 19

--------------------------------------------------

Partition after Iteration Number 9 :

--------------------------------------------------

3 4 5 6 7 8 9 10 11 20

1 12 14 15 16 17

2 13 18 19

--------------------------------------------------

Partition after Iteration Number 10 :

--------------------------------------------------

2 4 5 6 7 8 9 10 11 20

1 12 14 15 16 17

3 13 18 19

--------------------------------------------------

Partition after Iteration Number 11 :

--------------------------------------------------

2 3 4 6 7 8 9 10 11 20

1 12 14 15 16 17

5 13 18 19

--------------------------------------------------

Partition after Iteration Number 12 :

--------------------------------------------------

1 3 4 6 7 8 9 10 11 20

2 12 14 15 16 17

5 13 18 19

--------------------------------------------------

Partition after Iteration Number 13 :

--------------------------------------------------

2 3 4 6 7 8 9 10 11 20

1 12 14 15 16 17

5 13 18 19

--------------------------------------------------

Partition after Iteration Number 14 :

--------------------------------------------------

2 3 4 6 7 8 9 10 11 20

1 12 15 16 17 19

5 13 14 18

--------------------------------------------------

Partition after Iteration Number 15 :

--------------------------------------------------

1 2 3 6 7 8 9 10 11 20

4 12 15 16 17 19

5 13 14 18

--------------------------------------------------

Partition after Iteration Number 16 :

--------------------------------------------------

1 2 3 6 7 8 9 10 11 20

5 12 15 16 17 19

4 13 14 18

--------------------------------------------------

Partition after Iteration Number 17 :

--------------------------------------------------

2 3 4 6 7 8 9 10 11 20

5 12 15 16 17 19

1 13 14 18

--------------------------------------------------

Partition after Iteration Number 18 :

--------------------------------------------------

3 4 5 6 7 8 9 10 11 20

2 12 15 16 17 19

1 13 14 18

--------------------------------------------------

Partition after Iteration Number 19 :

--------------------------------------------------

2 4 5 6 7 8 9 10 11 20

3 12 15 16 17 19

1 13 14 18

--------------------------------------------------

Partition after Iteration Number 20 :

--------------------------------------------------

3 4 5 6 7 8 9 10 11 20

2 12 15 16 17 19

1 13 14 18

--------------------------------------------------

Partition after Iteration Number 21 :

--------------------------------------------------

3 4 5 6 7 8 9 10 11 20

1 12 15 16 17 19

2 13 14 18

--------------------------------------------------

Partition after Iteration Number 22 :

--------------------------------------------------

1 4 5 6 7 8 9 10 11 20

3 12 15 16 17 19

2 13 14 18

--------------------------------------------------

Partition after Iteration Number 23 :

--------------------------------------------------

1 4 6 7 8 9 10 11 13 20

3 12 15 16 17 19

2 5 14 18

--------------------------------------------------

Partition after Iteration Number 24 :

--------------------------------------------------

1 4 6 7 8 9 10 11 13 20

2 12 15 16 17 19

3 5 14 18

--------------------------------------------------

Partition after Iteration Number 25 :

--------------------------------------------------

1 4 6 7 8 9 10 11 13 20

3 12 15 16 17 19

2 5 14 18

--------------------------------------------------

Partition after Iteration Number 26 :

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1 4 6 7 8 9 10 11 13 20

2 12 15 16 17 19

3 5 14 18

--------------------------------------------------

Partition after Iteration Number 27 :

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1 4 6 7 8 9 10 11 13 20

3 12 15 16 17 19

2 5 14 18

--------------------------------------------------

Partition after Iteration Number 28 :

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3 4 6 7 8 9 10 11 13 20

1 12 15 16 17 19

2 5 14 18

--------------------------------------------------

Partition after Iteration Number 29 :

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2 4 6 7 8 9 10 11 13 20

1 12 15 16 17 19

3 5 14 18

--------------------------------------------------

Partition after Iteration Number 30 :

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2 4 6 7 8 9 10 11 13 20

3 12 15 16 17 19

1 5 14 18

--------------------------------------------------

Partition after Iteration Number 31 :

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1 4 6 7 8 9 10 11 13 20

3 12 15 16 17 19

2 5 14 18

--------------------------------------------------

Partition after Iteration Number 32 :

--------------------------------------------------

1 4 5 6 8 9 10 11 13 20

3 12 15 16 17 19

2 7 14 18

--------------------------------------------------

Partition after Iteration Number 33 :

--------------------------------------------------

1 4 5 6 8 9 10 11 13 20

2 12 15 16 17 19

3 7 14 18

--------------------------------------------------

Partition after Iteration Number 34 :

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2 4 5 6 8 9 10 11 13 20

1 12 15 16 17 19

3 7 14 18

--------------------------------------------------

Partition after Iteration Number 35 :

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2 4 5 6 8 9 10 11 13 20

3 12 15 16 17 19

1 7 14 18

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Partition after Iteration Number 36 :

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3 4 5 6 8 9 10 11 13 20

2 12 15 16 17 19

1 7 14 18

--------------------------------------------------

Partition after Iteration Number 37 :

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2 4 5 6 8 9 10 11 13 20

3 12 15 16 17 19

1 7 14 18

--------------------------------------------------

Partition after Iteration Number 38 :

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3 4 5 6 8 9 10 11 13 20

2 12 15 16 17 19

1 7 14 18

--------------------------------------------------

Partition after Iteration Number 39 :

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3 4 5 6 8 9 10 11 13 20

1 12 15 16 17 19

2 7 14 18

--------------------------------------------------

Partition after Iteration Number 40 :

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3 4 5 6 8 9 10 11 13 20

2 12 15 16 17 19

1 7 14 18

--------------------------------------------------

Partition after Iteration Number 41 :

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3 4 5 6 8 9 10 11 13 20

1 12 15 16 17 19

2 7 14 18

--------------------------------------------------

Partition after Iteration Number 42 :

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3 4 5 6 8 9 10 11 13 20

2 12 15 16 17 19

1 7 14 18

--------------------------------------------------

Partition after Iteration Number 43 :

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3 4 5 6 8 9 10 11 13 20

1 12 15 16 17 19

2 7 14 18

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Partition after Iteration Number 44 :

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3 4 5 6 8 9 10 11 13 20

2 12 15 16 17 19

1 7 14 18

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Partition after Iteration Number 45 :

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2 4 5 6 8 9 10 11 13 20

3 12 15 16 17 19

1 7 14 18

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Partition after Iteration Number 46 :

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2 4 5 6 8 9 10 11 13 20

1 12 15 16 17 19

3 7 14 18

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Partition after Iteration Number 47 :

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2 4 5 6 8 9 10 11 13 20

3 12 15 16 17 19

1 7 14 18

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Partition after Iteration Number 48 :

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1 4 5 6 8 9 10 11 13 20

3 12 15 16 17 19

2 7 14 18

--------------------------------------------------

Partition after Iteration Number 49 :

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2 4 5 6 8 9 10 11 13 20

3 12 15 16 17 19

1 7 14 18

--------------------------------------------------

Partition after Iteration Number 50 :

--------------------------------------------------

1 4 5 6 8 9 10 11 13 20

3 12 15 16 17 19

2 7 14 18

--------------------------------------------------

Final Partition List :

--------------------------------------------------

1 4 5 6 8 9 10 11 13 20

3 12 15 16 17 19

2 7 14 18

**CONCLUSION :**

KL algorithm is an NP complete problem therefore we adopt the method of heuristics to reduce the Cut Cost. If we increase our number of iterations we can achieve the optimal cut cost. But it causes an increase in the runtime and memory. So a tradeoff needs to be taken for finding the optimal solution at minimum time and minimal resources.