Northeastern University

EECE 7205 - FUNDAMENTALS OF COMPUTER ENGINEERING
PROJECT 2

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Explanation

- This program is about scheduling tasks to local cores of a mobile device or cloud for execution
- The task scheduling algorithm has two steps:
  - Initial Scheduling
  - Task Migration
- The task scheduling is done in a way that it satisfies two cases:
  - Minimum execution time taken by the mobile device’s local core or cloud to execute the task
  - Efficient Energy consumption for executing the tasks

Explanation (Contd.)

- Initial Scheduling:
  - First the tasks are initialized based on the weights of each tasks which includes the time taken by each task and checking for the predecessors for a task to execute
  - In this scheduling the tasks are shared between the local cores and cloud and executed based on the execution time without the constraint of energy efficiency
- After Migration:
  - Here energy constraints are also considered for each task and the tasks are scheduled to the local cores and cloud again to reach the minimal energy consumption

Explanation (Contd.)

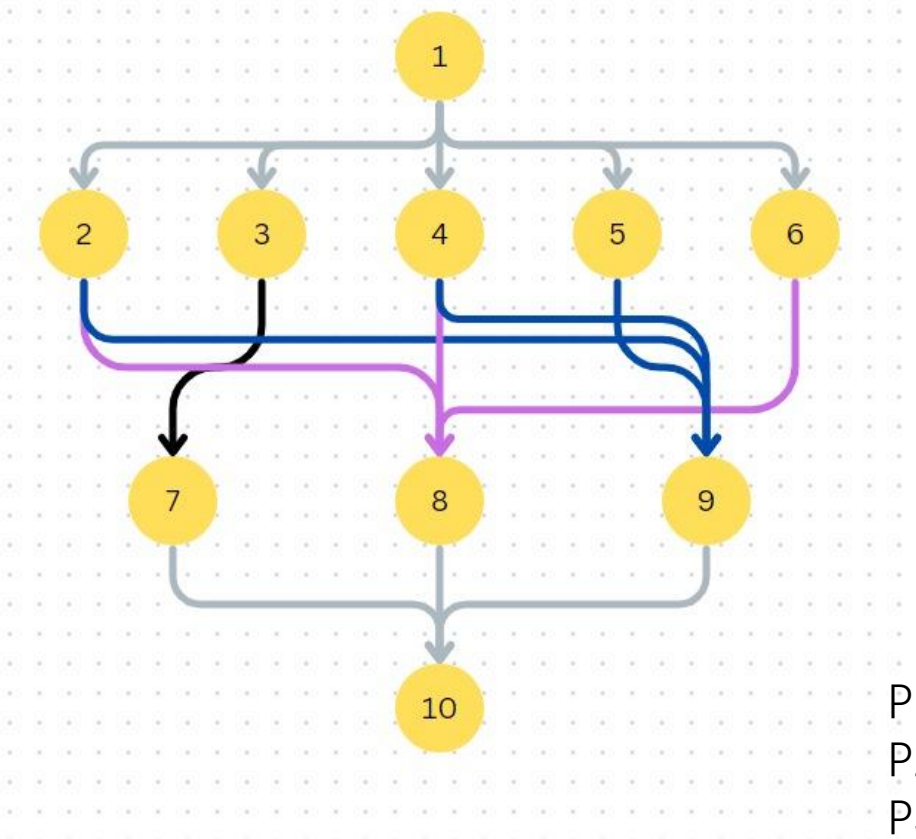
The MCC (Mobile Cloud Computing) algorithm has two phases:

- Phase 1 Initial Scheduling:
  - Primary assignment: It calculates the minimum execution time for each task on the available cores and it also classifies tasks into local or cloud based on the time constraint
  - Task Prioritization: The tasks are sorted in a priority queue based on the primary assignment and the predecessors and dependencies of the tasks
  - Execution: Implements the scheduling algorithm for the task execution on the cores or cloud and it also determines the start and end time of a task

Explanation (Contd.)

- Phase 2:
  - Outer loop: This algorithm determines whether the tasks should be rescheduled to minimize the time consumption (i.e.,) it determines the required task to migrate from the initially scheduled core to different local (core) or cloud to improve time efficiency
  - Kernel: It implements the scheduling algorithm to minimize the energy consumption within the given time constraint by rescheduling the tasks from its initially scheduled channel (cores and cloud) to another possible channel with minimal energy and time consumption

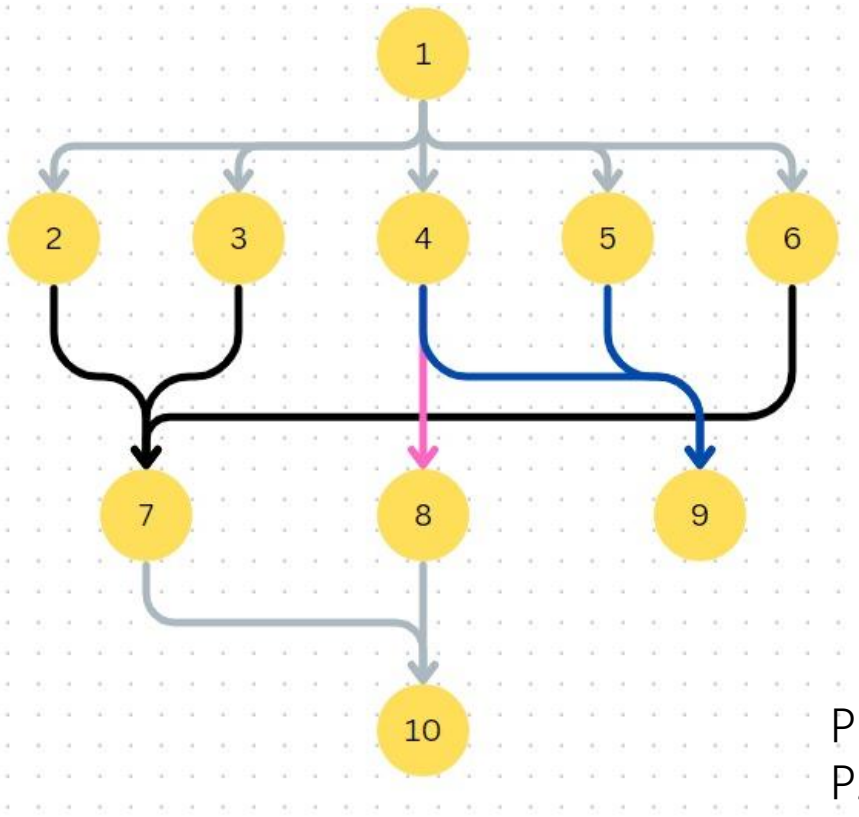
First Input:



P1=1
P2=2
P3=4
Pws=0.5
Tmax =27

Time in each core	local core1	local core2	local core3
Task 1	9	7	5
Task 2	8	6	5
Task 3	6	5	4
Task 4	7	5	3
Task 5	5	4	2
Task 6	7	6	4
Task 7	8	5	3
Task 8	6	4	2
Task 9	5	3	2
Task 10	7	4	2

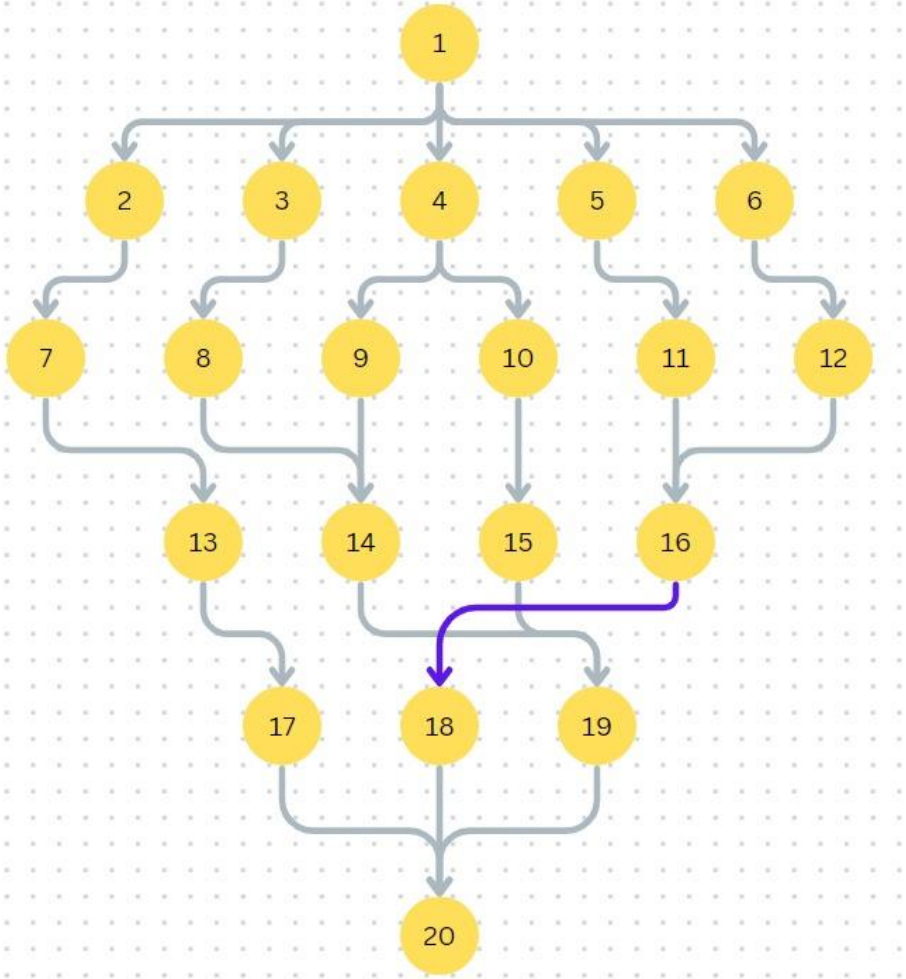
Second Input



P1=1
P2=2
P3=4
Pws=0.5
Tmax =27

Time in each core	local core1	local core2	local core3
Task 1	9	7	5
Task 2	8	6	5
Task 3	6	5	4
Task 4	7	5	3
Task 5	5	4	2
Task 6	7	6	4
Task 7	8	5	3
Task 8	6	4	2
Task 9	5	3	2
Task 10	7	4	2

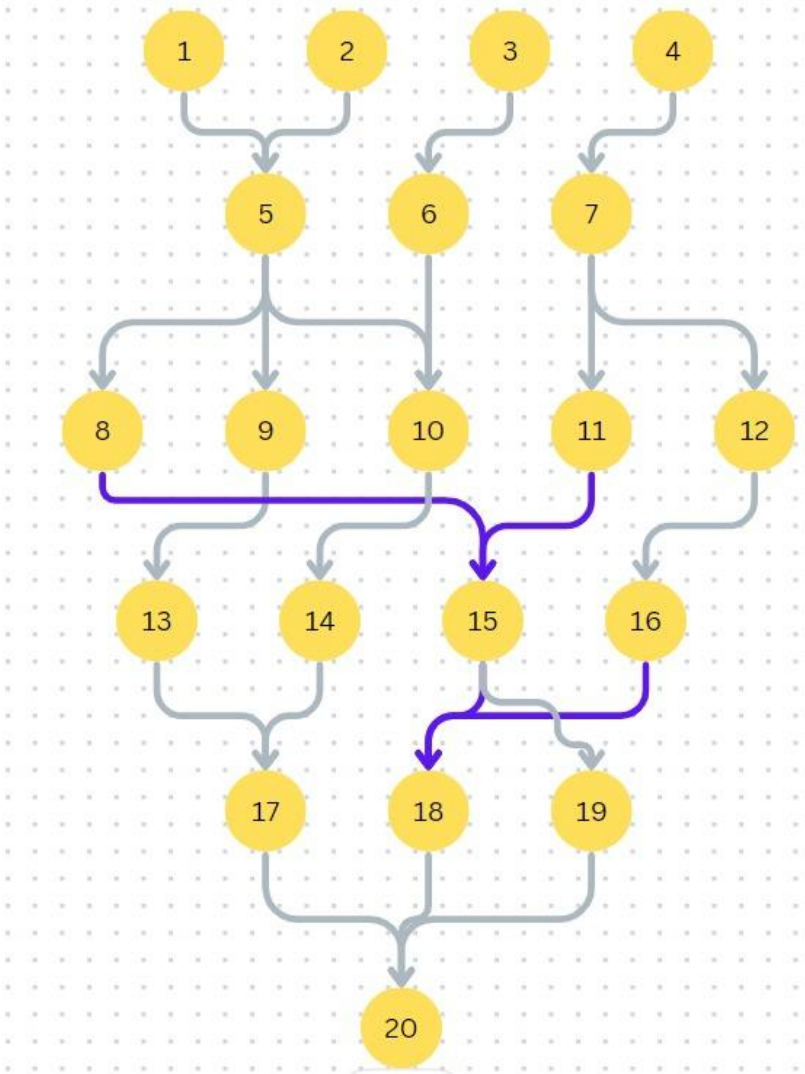
Third Input



P1=1
P2=2
P3=4
Pws=0.5
Tmax =50

Time in each core	Local core1	Local core2	Local core3
Task 1	9	7	5
Task 2	8	6	5
Task 3	6	5	4
Task 4	7	5	3
Task 5	5	4	2
Task 6	7	6	4
Task 7	8	5	3
Task 8	6	4	2
Task 9	5	3	2
Task 10	7	4	2
Task 11	8	6	1
Task 12	7	3	2
Task 13	9	5	4
Task 14	5	3	1
Task 15	7	3	2
Task 16	8	4	2
Task 17	7	6	5
Task 18	9	2	1
Task 19	6	3	1
Task 20	7	4	2

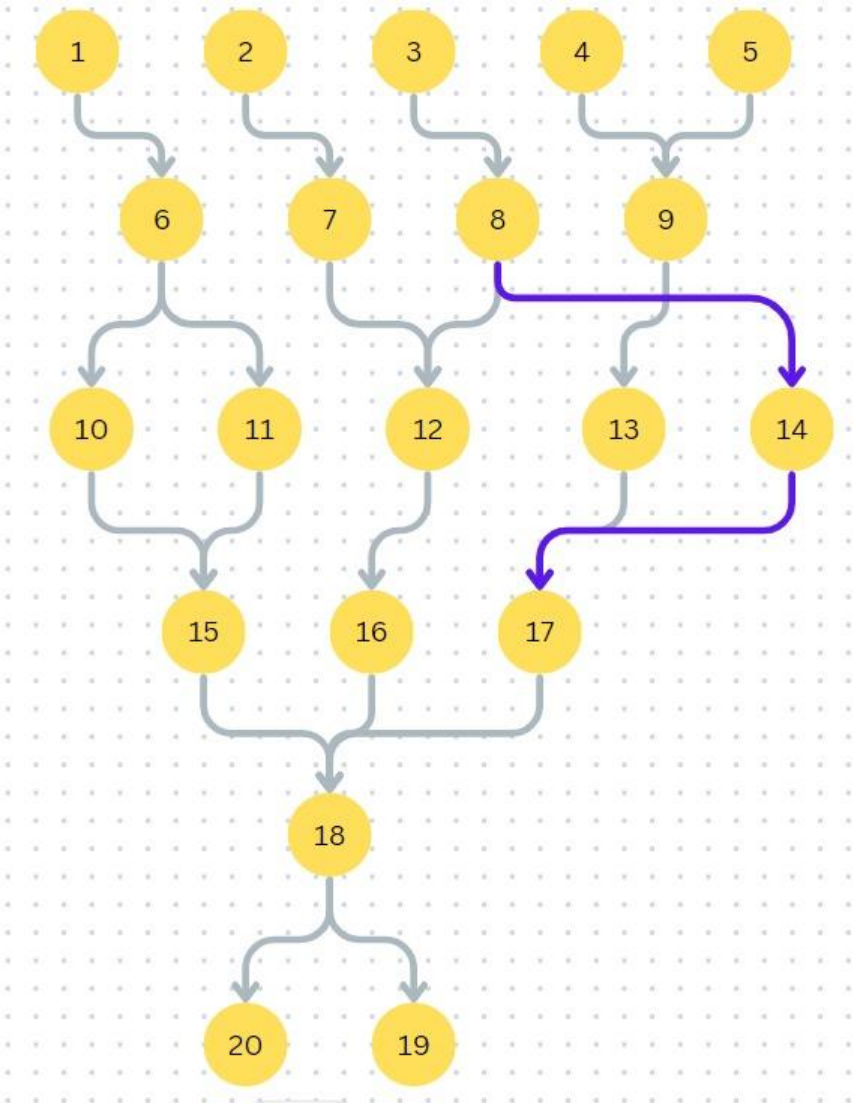
Fourth Input



P1=1
P2=2
P3=4
Pws=0.5
Tmax =50

Time in each core	Local core1	Local core2	Local core3
Task 1	9	7	5
Task 2	8	6	5
Task 3	6	5	4
Task 4	7	5	3
Task 5	5	4	2
Task 6	7	6	4
Task 7	8	5	3
Task 8	6	4	2
Task 9	5	3	2
Task 10	7	4	2
Task 11	8	6	1
Task 12	7	3	2
Task 13	9	5	4
Task 14	5	3	1
Task 15	7	3	2
Task 16	8	4	2
Task 17	7	6	5
Task 18	9	2	1
Task 19	6	3	1
Task 20	7	4	2

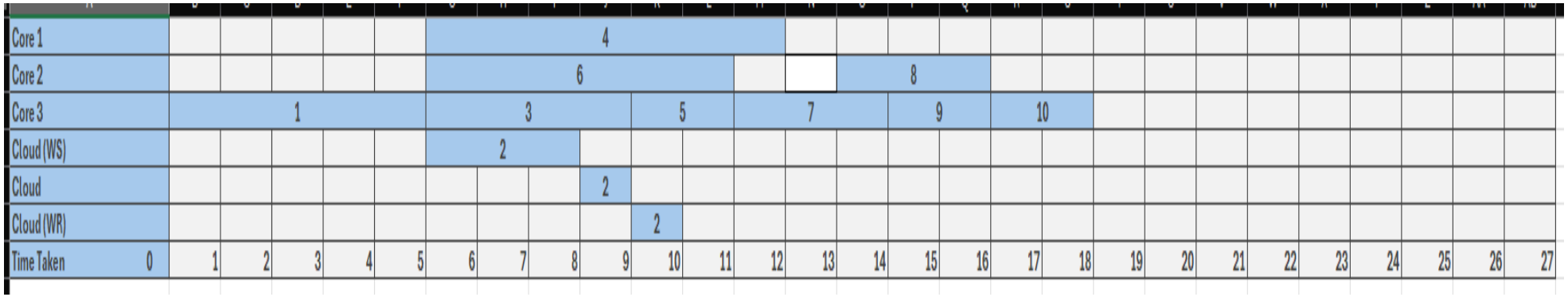
Fifth Input



P1=1
P2=2
P3=4
Pws=0.5
Tmax =50

Time in each core	Local core1	Local core2	Local core3
Task 1	9	7	5
Task 2	8	6	5
Task 3	6	5	4
Task 4	7	5	3
Task 5	5	4	2
Task 6	7	6	4
Task 7	8	5	3
Task 8	6	4	2
Task 9	5	3	2
Task 10	7	4	2
Task 11	8	6	1
Task 12	7	3	2
Task 13	9	5	4
Task 14	5	3	1
Task 15	7	3	2
Task 16	8	4	2
Task 17	7	6	5
Task 18	9	2	1
Task 19	6	3	1
Task 20	7	4	2

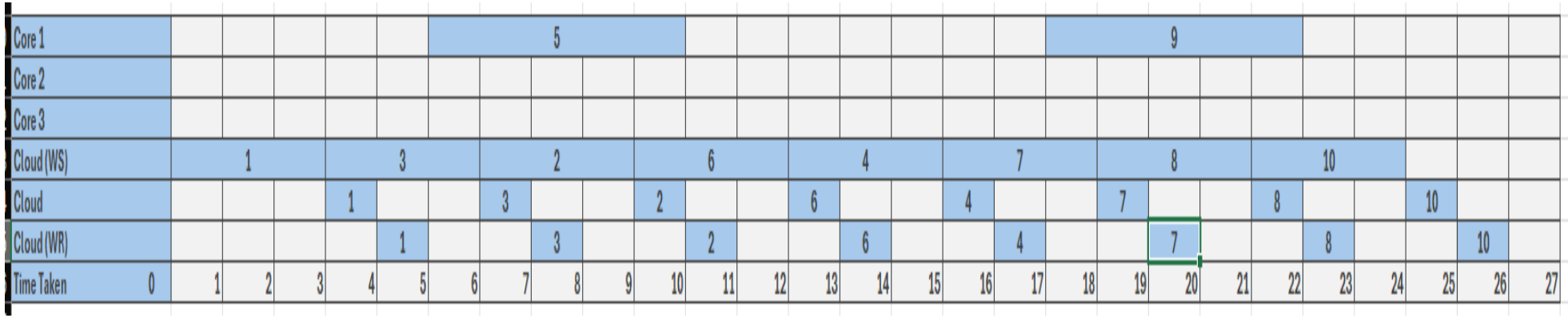
Output for the input 1 after initial schedule



Core 1						4																						
Core 2						6							8															
Core 3	1					3			5			7			9		10											
Cloud (WS)						2																						
Cloud									2																			
Cloud (WR)										2																		
Time Taken	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27

Energy, E= 100.5

Output for the input 1 after migration - Final schedule



Core 1						5												9										
Core 2																												
Core 3																												
Cloud (WS)	1			3			2			6			4			7			8			10						
Cloud				1			3			2			6			4			7			8			10			
Cloud (WR)					1			3			2			6			4			7			8			10		
Time Taken	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27

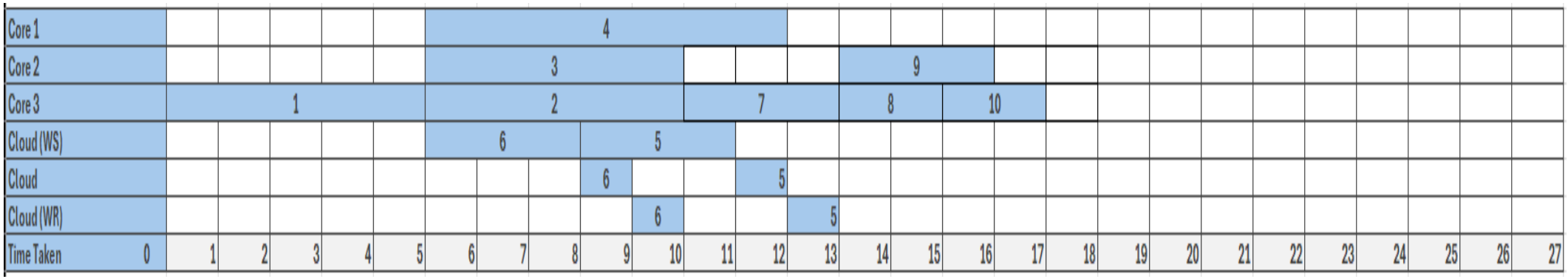
Energy, E= 22

Energy Consumption for Input 1:

```
Initial schedule:
Task1: local core3, start time is: 0,finish time is: 5
Task3: local core3, start time is: 5,finish time is: 9
Task2: cloud, start time is: 5,finish time is: 10
Task6: local core2, start time is: 5,finish time is: 11
Task4: local core1, start time is: 5,finish time is: 12
Task5: local core3, start time is: 9,finish time is: 11
Task7: local core3, start time is: 11,finish time is: 14
Task8: local core2, start time is: 12,finish time is: 16
Task9: local core3, start time is: 14,finish time is: 16
Task10: local core3, start time is: 16,finish time is: 18
 Now the total energy is: 100.5
 Now the completion time is: 18
Running time of initial schedule of Graph is 0.027 ms
```

```
After Task Migration:
Task1: cloud, start time is: 0,finish time is: 5
Task3: cloud, start time is: 3,finish time is: 8
Task2: cloud, start time is: 6,finish time is: 11
Task6: cloud, start time is: 9,finish time is: 14
Task4: cloud, start time is: 12,finish time is: 17
Task5: local core1, start time is: 5,finish time is: 10
Task7: cloud, start time is: 15,finish time is: 20
Task8: cloud, start time is: 18,finish time is: 23
Task9: local core1, start time is: 17,finish time is: 22
Task10: cloud, start time is: 22,finish time is: 27
 Now the total energy is: 22
 Now the completion time is: 27
Running time of task migration of Graph is 1.711 ms
```

Output for the input 2 after initial schedule



Energy, E= 94

Output for the input 2 after migration - Final schedule

Core 1																		8										
Core 2																												
Core 3																									10			
Cloud (WS)	1			2			6			3			4			7			5			9						
Cloud				1			2			6			3			4			7			5			9			
Cloud (WR)					1			2			6			3			4			7			5			9		
Time Taken 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	

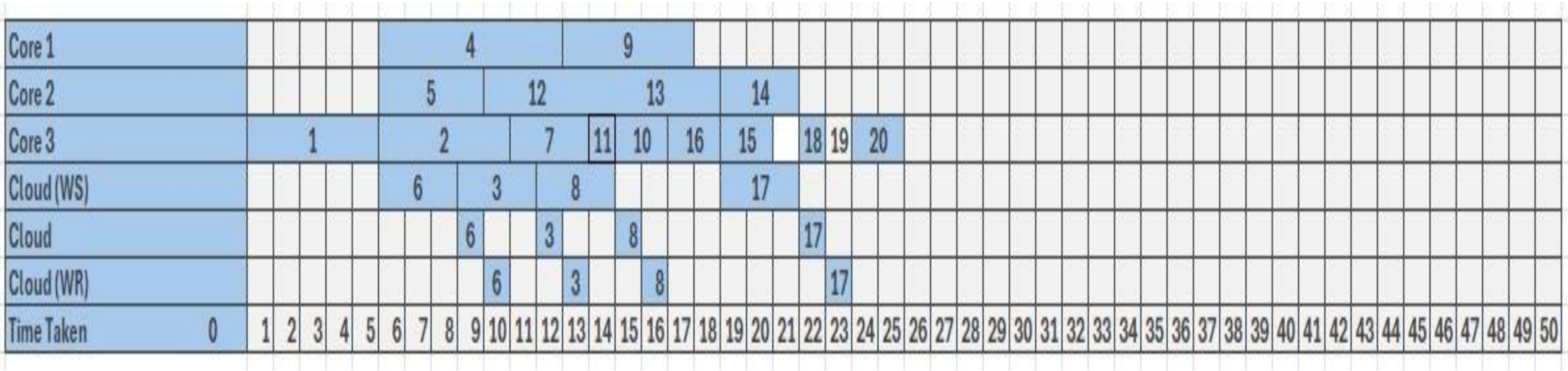
Energy, E= 26

Energy Consumption for Input 2:

```
Initial schedule:
Task1: local core3, start time is: 0,finish time is: 5
Task2: local core3, start time is: 5,finish time is: 10
Task6: cloud, start time is: 5,finish time is: 10
Task3: local core2, start time is: 5,finish time is: 10
Task4: local core1, start time is: 5,finish time is: 12
Task7: local core3, start time is: 10,finish time is: 13
Task8: local core3, start time is: 13,finish time is: 15
Task5: cloud, start time is: 8,finish time is: 13
Task10: local core3, start time is: 15,finish time is: 17
Task9: local core2, start time is: 13,finish time is: 16
 Now the total energy is: 94
 Now the completion time is: 17
Running time of initial schedule of Graph is 0.025 ms
```

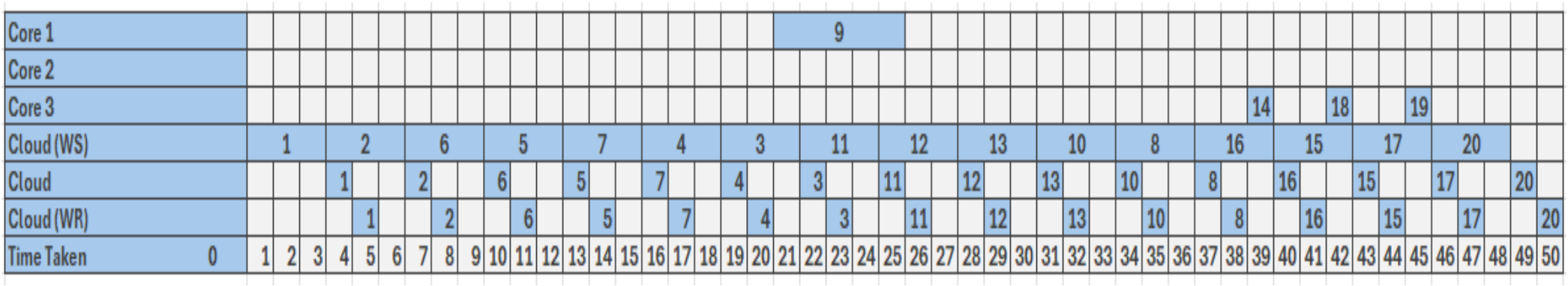
```
After Task Migration:
Task1: cloud, start time is: 0,finish time is: 5
Task2: cloud, start time is: 3,finish time is: 8
Task6: cloud, start time is: 6,finish time is: 11
Task3: cloud, start time is: 9,finish time is: 14
Task4: cloud, start time is: 12,finish time is: 17
Task7: cloud, start time is: 15,finish time is: 20
Task8: local core1, start time is: 17,finish time is: 23
Task5: cloud, start time is: 18,finish time is: 23
Task10: local core3, start time is: 23,finish time is: 25
Task9: cloud, start time is: 21,finish time is: 26
 Now the total energy is: 26
 Now the completion time is: 26
Running time of task migration of Graph is 1.837 ms
```

Output for the input 3 after initial schedule



Energy, E= 144

Output for the input 3 after migration - Final schedule



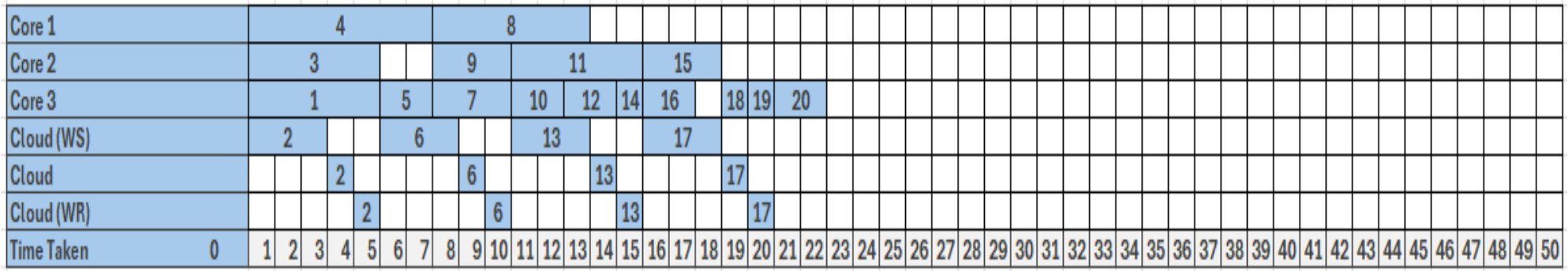
Energy, E= 41

Energy Consumption for Input 3:

```
Initial schedule:
Task1: local core3, start time is: 0,finish time is: 5
Task2: local core3, start time is: 5,finish time is: 10
Task6: cloud, start time is: 5,finish time is: 10
Task5: local core2, start time is: 5,finish time is: 9
Task7: local core3, start time is: 10,finish time is: 13
Task4: local core1, start time is: 5,finish time is: 12
Task3: cloud, start time is: 8,finish time is: 13
Task11: local core3, start time is: 13,finish time is: 14
Task12: local core2, start time is: 10,finish time is: 13
Task13: local core2, start time is: 13,finish time is: 18
Task10: local core3, start time is: 14,finish time is: 16
Task8: cloud, start time is: 11,finish time is: 16
Task9: local core1, start time is: 12,finish time is: 17
Task16: local core3, start time is: 16,finish time is: 18
Task15: local core3, start time is: 18,finish time is: 20
Task14: local core2, start time is: 18,finish time is: 21
Task17: cloud, start time is: 18,finish time is: 23
Task18: local core3, start time is: 20,finish time is: 21
Task19: local core3, start time is: 21,finish time is: 22
Task20: local core3, start time is: 23,finish time is: 25
 Now the total energy is: 144
 Now the completion time is: 25
Running time of initial schedule of Graph is 0.042 ms
```

```
After Task Migration:
Task1: cloud, start time is: 0,finish time is: 5
Task2: cloud, start time is: 3,finish time is: 8
Task6: cloud, start time is: 6,finish time is: 11
Task5: cloud, start time is: 9,finish time is: 14
Task7: cloud, start time is: 12,finish time is: 17
Task4: cloud, start time is: 15,finish time is: 20
Task3: cloud, start time is: 18,finish time is: 23
Task11: cloud, start time is: 21,finish time is: 26
Task12: cloud, start time is: 24,finish time is: 29
Task13: cloud, start time is: 27,finish time is: 32
Task10: cloud, start time is: 30,finish time is: 35
Task8: cloud, start time is: 33,finish time is: 38
Task9: local core1, start time is: 20,finish time is: 25
Task16: cloud, start time is: 36,finish time is: 41
Task15: cloud, start time is: 39,finish time is: 44
Task14: local core3, start time is: 38,finish time is: 39
Task17: cloud, start time is: 42,finish time is: 47
Task18: local core3, start time is: 41,finish time is: 42
Task19: local core3, start time is: 44,finish time is: 45
Task20: cloud, start time is: 45,finish time is: 50
 Now the total energy is: 41
 Now the completion time is: 50
Running time of task migration of Graph is 25.671 ms
```

Output for the input 4 after initial schedule



Energy, E= 127

Output for the input 4 after migration - Final schedule

Core 1																																																		
Core 2																																	15																	
Core 3																																							16		18	19								
Cloud (WS)	1			2			3			4			5			6			7			9			10			11			8			12			13			14			17			20				
Cloud				1			2			3			4			5			6			7			9			10			11			8			12			13			14			17			20	
Cloud (WR)					1			2			3			4			5			6			7			9			10			11			8			12			13			14			17			20
Time Taken 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50

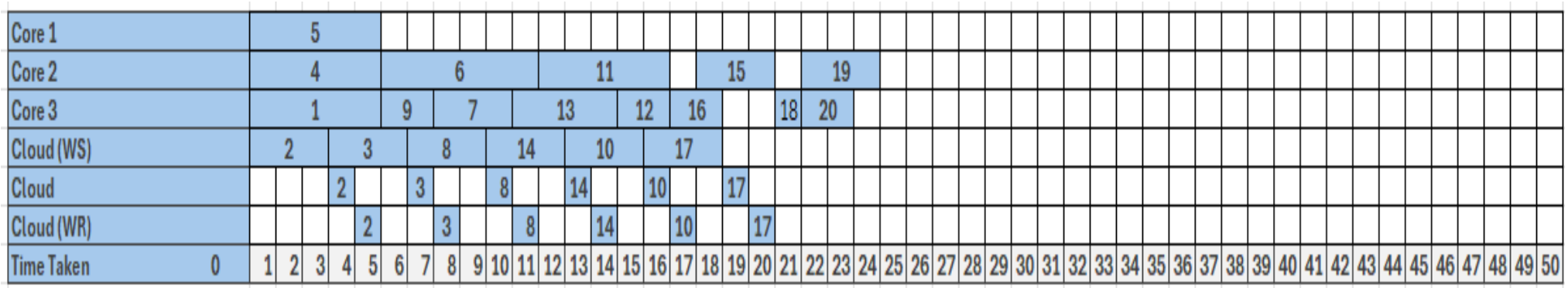
Energy, E= 46

Energy Consumption for Input 4:

```
Initial schedule:
Task1: local core3, start time is: 0,finish time is: 5
Task2: cloud, start time is: 0,finish time is: 5
Task3: local core2, start time is: 0,finish time is: 5
Task4: local core1, start time is: 0,finish time is: 7
Task5: local core3, start time is: 5,finish time is: 7
Task6: cloud, start time is: 5,finish time is: 10
Task7: local core3, start time is: 7,finish time is: 10
Task9: local core2, start time is: 7,finish time is: 10
Task10: local core3, start time is: 10,finish time is: 12
Task11: local core3, start time is: 12,finish time is: 13
Task12: local core2, start time is: 10,finish time is: 13
Task8: local core1, start time is: 7,finish time is: 13
Task13: cloud, start time is: 10,finish time is: 15
Task14: local core3, start time is: 13,finish time is: 14
Task16: local core3, start time is: 14,finish time is: 16
Task15: local core2, start time is: 13,finish time is: 16
Task17: cloud, start time is: 14,finish time is: 19
Task18: local core3, start time is: 16,finish time is: 17
Task19: local core3, start time is: 17,finish time is: 18
Task20: local core3, start time is: 19,finish time is: 21
 Now the total energy is: 127
 Now the completion time is: 21
Running time of initial schedule of Graph is 0.061 ms
```

```
After Task Migration:
Task1: cloud, start time is: 0,finish time is: 5
Task2: cloud, start time is: 3,finish time is: 8
Task3: cloud, start time is: 6,finish time is: 11
Task4: cloud, start time is: 9,finish time is: 14
Task5: cloud, start time is: 12,finish time is: 17
Task6: cloud, start time is: 15,finish time is: 20
Task7: cloud, start time is: 18,finish time is: 23
Task9: cloud, start time is: 21,finish time is: 26
Task10: cloud, start time is: 24,finish time is: 29
Task11: cloud, start time is: 27,finish time is: 32
Task12: cloud, start time is: 30,finish time is: 35
Task8: cloud, start time is: 33,finish time is: 38
Task13: cloud, start time is: 36,finish time is: 41
Task14: cloud, start time is: 39,finish time is: 44
Task16: local core3, start time is: 35,finish time is: 37
Task15: local core2, start time is: 38,finish time is: 41
Task17: cloud, start time is: 42,finish time is: 47
Task18: local core3, start time is: 41,finish time is: 42
Task19: local core3, start time is: 42,finish time is: 43
Task20: cloud, start time is: 45,finish time is: 50
 Now the total energy is: 46
 Now the completion time is: 50
Running time of task migration of Graph is 28.499 ms
```

Output for the input 5 after initial schedule



Energy, E= 142.5

Output for the input 5 after migration - Final schedule

Core 1																																																			
Core 2																															12												15			18	19				
Core 3																																		16																	
Cloud (WS)		1			2			4			5			3			9			6			7			8			13			11			14			10			17						20				
Cloud					1			2			4			5			3			9			6			7			8			13			11			14			10			17						20	
Cloud (WR)						1			2			4			5			3			9			6			7			8			13			11			14			10			17						20
Time Taken	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50

Energy, E= 45

Energy Consumption for Input 5:

```
Initial schedule:
Task1: local core3, start time is: 0,finish time is: 5
Task2: cloud, start time is: 0,finish time is: 5
Task4: local core2, start time is: 0,finish time is: 5
Task5: local core1, start time is: 0,finish time is: 5
Task3: cloud, start time is: 3,finish time is: 8
Task9: local core3, start time is: 5,finish time is: 7
Task6: local core2, start time is: 5,finish time is: 11
Task7: local core3, start time is: 7,finish time is: 10
Task8: cloud, start time is: 6,finish time is: 11
Task13: local core3, start time is: 10,finish time is: 14
Task11: local core3, start time is: 14,finish time is: 15
Task14: local core2, start time is: 11,finish time is: 14
Task12: cloud, start time is: 10,finish time is: 15
Task10: local core3, start time is: 15,finish time is: 17
Task17: cloud, start time is: 14,finish time is: 19
Task16: local core2, start time is: 15,finish time is: 19
Task15: local core3, start time is: 17,finish time is: 19
Task18: local core3, start time is: 19,finish time is: 20
Task20: local core3, start time is: 20,finish time is: 22
Task19: local core2, start time is: 20,finish time is: 23
 Now the total energy is: 142.5
 Now the completion time is: 23
Running time of initial schedule of Graph is 0.064 ms
```

```
After Task Migration:
Task1: cloud, start time is: 0,finish time is: 5
Task2: cloud, start time is: 3,finish time is: 8
Task4: cloud, start time is: 6,finish time is: 11
Task5: cloud, start time is: 9,finish time is: 14
Task3: cloud, start time is: 12,finish time is: 17
Task9: cloud, start time is: 15,finish time is: 20
Task6: cloud, start time is: 18,finish time is: 23
Task7: cloud, start time is: 21,finish time is: 26
Task8: cloud, start time is: 24,finish time is: 29
Task13: cloud, start time is: 27,finish time is: 32
Task11: cloud, start time is: 30,finish time is: 35
Task14: local core3, start time is: 29,finish time is: 30
Task12: cloud, start time is: 33,finish time is: 38
Task10: local core1, start time is: 23,finish time is: 30
Task17: cloud, start time is: 36,finish time is: 41
Task16: cloud, start time is: 39,finish time is: 44
Task15: local core2, start time is: 35,finish time is: 38
Task18: cloud, start time is: 42,finish time is: 47
Task20: cloud, start time is: 45,finish time is: 50
Task19: local core3, start time is: 47,finish time is: 48
 Now the total energy is: 45
 Now the completion time is: 50
Running time of task migration of Graph is 27.533 ms
```

REFERENCES

[1] X. Lin, Y. Wang, Q. Xie and M. Pedram, "Energy and Performance-Aware Task Scheduling in a Mobile Cloud Computing Environment," *2014 IEEE 7th International Conference on Cloud Computing*, Anchorage, AK, 2014, pp. 192-199, doi: 10.1109/CLOUD.2014.35.