Task Scheduling Implementation
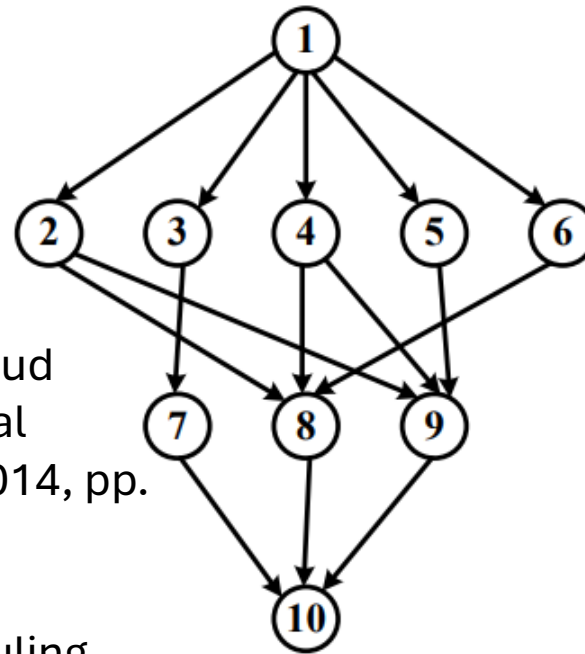
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Test case #1 Example used in the paper

Task	Core1	Core2	Core3
1	9	7	5
2	8	6	5
3	6	5	4
4	7	5	3
5	5	4	2
6	7	6	4
7	8	5	3
8	6	4	2
9	5	3	2
10	7	4	2

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

Initial Scheduling Results, Results Plot, Final Scheduling Results, Results Plot & Comparison to the one in the paper.

$$1 \le i \le N, \begin{cases} T_i^s = 3 \\ T_i^c = 1 \\ T_i^r = 1 \end{cases}$$

#1 Initial Scheduling Results (100.5)


```
project 2.cpp

Microsoft Visual Studio Debug Console
initial time: 18
initial energy: 100.5
Node ID: 1, Assignment: Core 3, Local Start time: 0, Local Finish time: 5
Node ID: 2, Assignment: Cloud, Cloud Start time: 8, Cloud Finish time: 9, WS Start
time: 9, WR Finish time: 10
Node ID: 3, Assignment: Core 3, Local Start time: 5, Local Finish time: 9
Node ID: 4, Assignment: Core 1, Local Start time: 5, Local Finish time: 12
Node ID: 5, Assignment: Core 3, Local Start time: 9, Local Finish time: 11
Node ID: 6, Assignment: Core 2, Local Start time: 5, Local Finish time: 11
Node ID: 7, Assignment: Core 3, Local Start time: 11, Local Finish time: 14
Node ID: 8, Assignment: Core 2, Local Start time: 12, Local Finish time: 16
Node ID: 9, Assignment: Core 3, Local Start time: 14, Local Finish time: 16
Node ID: 10, Assignment: Core 3, Local Start time: 16, Local Finish time: 18
--------------------------------------------------------------------------
iter: 0
initial time: 18
initial energy: 100.5
--------------------------------------------------------------------------
```

Cloud =0.5
Energy = Power * time

$e1 = 7*1 = 7$
$e2 = 6*2 + 4*2 = 20$
$e3 = 5*4 + 4*4 + 2*4 + 3*4 + 4*2$
$+2*4= 72$

ecloud = 1*3*0.5 (node 2)
e_total = e1+e2+e3+ecloud = 100.5

#1 Initial Results Plot
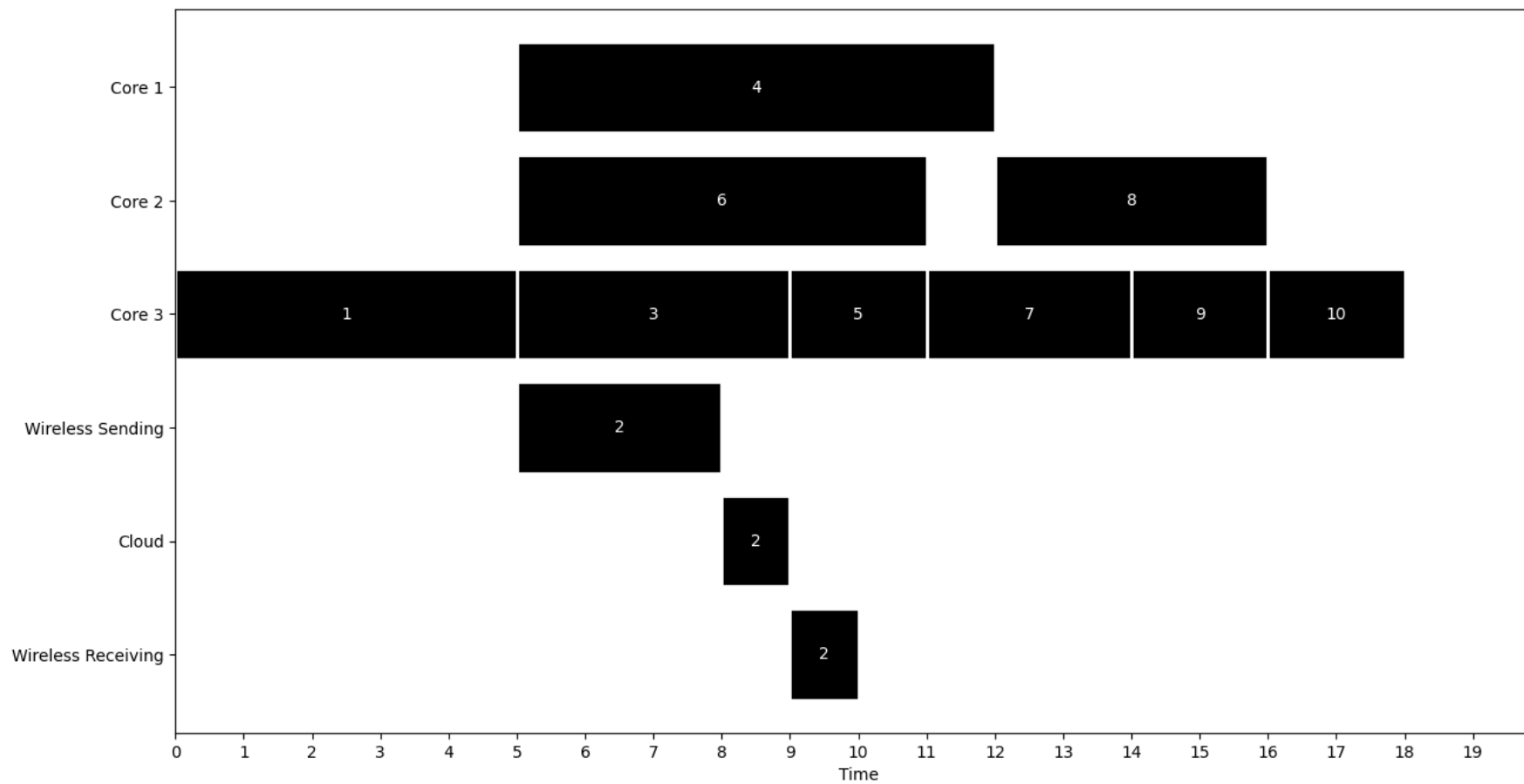
#1 Final Scheduling Results

energy = power * time

cloud count = 8 (node 1,2,5,6,3,8,7,10)

e1 = 7*1 + 5*1 = 12

e2 = 0

e3 = 0

ecloud = 8*3*0.5

e_total = e1+e2+e3+ecloud = 24

```
final sequence:
[4 9 ]
[]
[]
[1 2 5 6 3 8 7 10 ]

initial time: 18
initial energy: 100.5

final time: 26
final energy: 24

C:\Users\Lawrence\source\repos\idk\idk\x64\Debug\idk.exe (process 15640) exited with code 0 (0x0).
Press any key to close this window . . ._
```
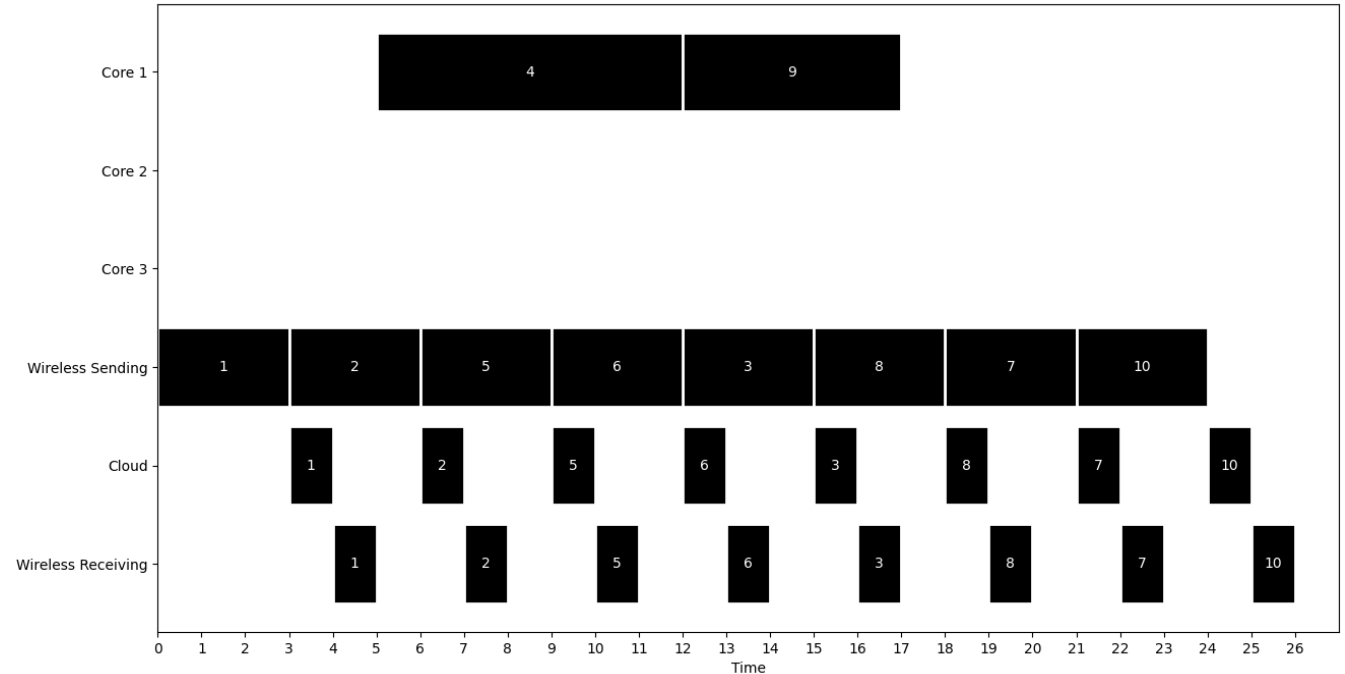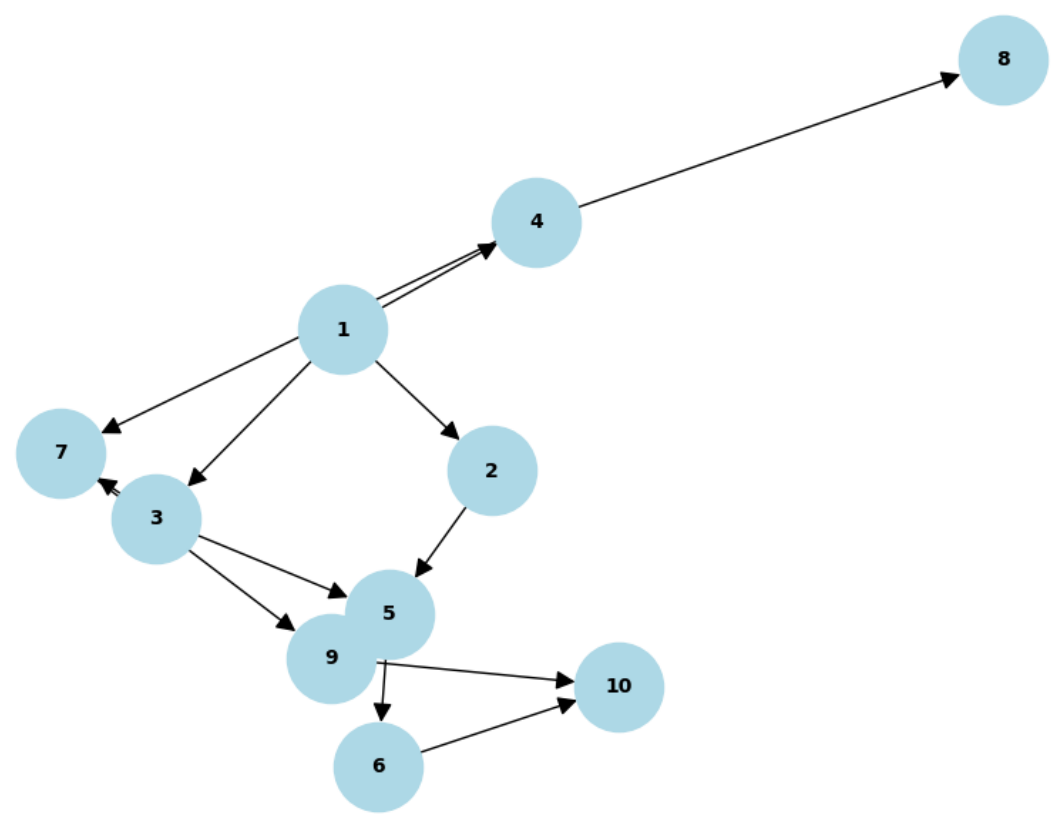
#1 Final Scheduling Results Plot & Comparison

> Calculations do not vary with the one in the Paper[1] for initial scheduling.

> In the final scheduling, e_total is 24 here instead of 27.

> Change in the ordering of nodes which may change priorities.

Test Case #2

Graph Representation

Node ID	Core1	Core2	Core3
1	9	7	5
2	8	6	5
3	6	5	4
4	7	5	4
5	5	4	2
6	7	6	5
7	8	5	4
8	6	4	2
9	9	7	3
10	7	4	2

#2 Initial Scheduling Results

```
Node ID: 1, Assignment: Core 3, Local Start time: 0, Local Finish time: 5
Node ID: 2, Assignment: Core 3, Local Start time: 5, Local Finish time: 10
Node ID: 3, Assignment: Cloud, Cloud Start time: 8, Cloud Finish time: 9, WS Start ti
time: 9, WR Finish time: 10
Node ID: 4, Assignment: Core 2, Local Start time: 5, Local Finish time: 10
Node ID: 5, Assignment: Core 3, Local Start time: 10, Local Finish time: 12
Node ID: 6, Assignment: Cloud, Cloud Start time: 15, Cloud Finish time: 16, WS Start
art time: 16, WR Finish time: 17
Node ID: 7, Assignment: Core 2, Local Start time: 10, Local Finish time: 15
Node ID: 8, Assignment: Core 3, Local Start time: 12, Local Finish time: 14
Node ID: 9, Assignment: Core 3, Local Start time: 15, Local Finish time: 17
Node ID: 10, Assignment: Core 3, Local Start time: 17, Local Finish time: 19
--------------------------------------------------------------------------
iter: 0
initial time: 19
initial energy: 95
```

energy = power * time

e1 = 0

e2 = 5*2 + 5*2 = 20

e3 = 5*4 + 5*4 + 2*4 + 2* 4+ 2*4 + 2*4

= 72

ecloud = 2*3*0.5 = 3

e_total = e1+e2+e3+ecloud = 95
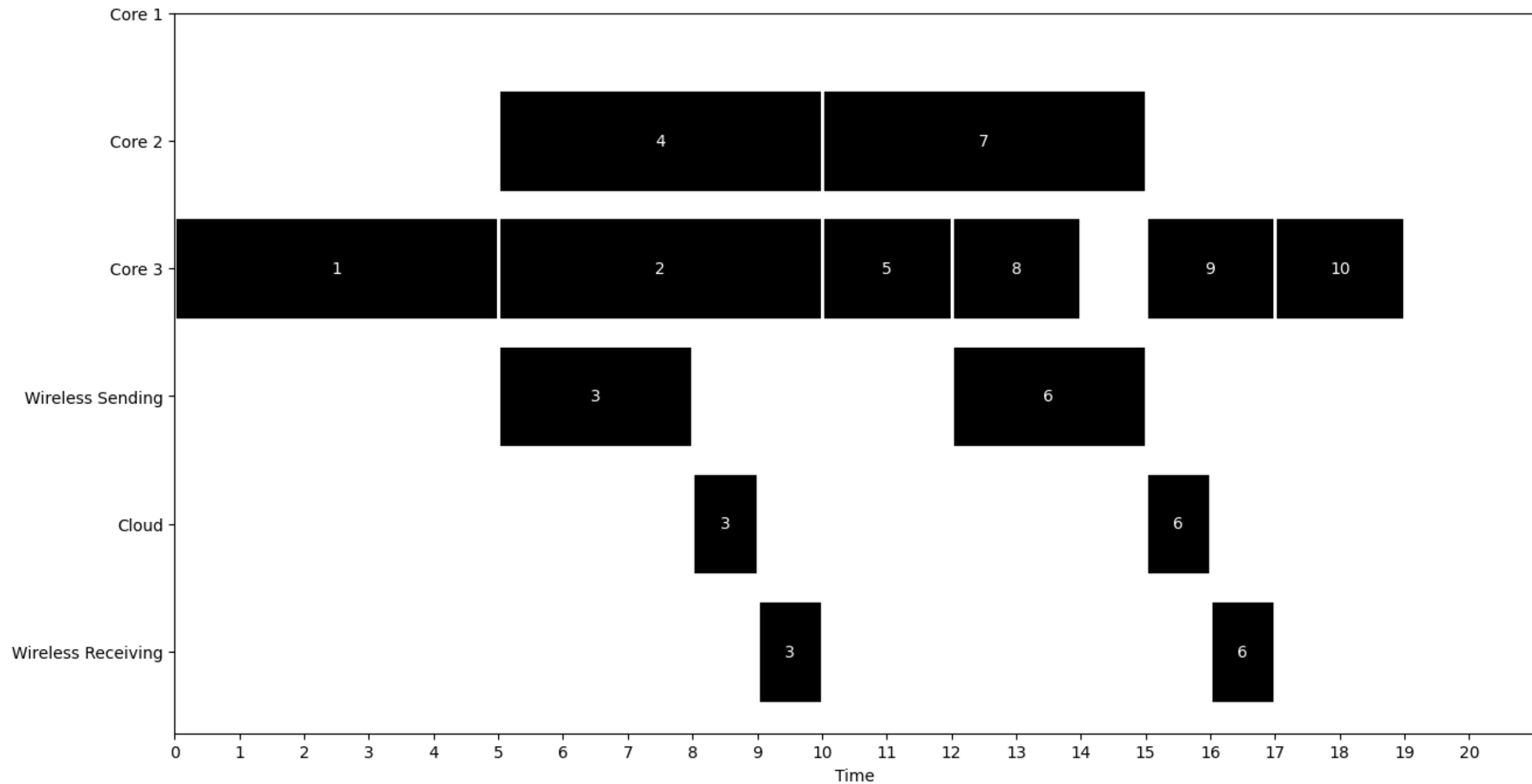
#2 Final Scheduling Results

```
final sequence:
[8 9 ]
[]
[10 ]
[1 3 4 2 7 5 6 ]

initial time: 19
initial energy: 95

final time: 25
final energy: 29.5

C:\Users\Lawrence\source\repos\idk\idk\x64\Debug\idk.exe (process 16516) exited with code 0 (0x0).
Press any key to close this window . . .
```

core 1 count = 2 (node 8,9)
core 2 count = 0
core 3 count = 1 (node 10)
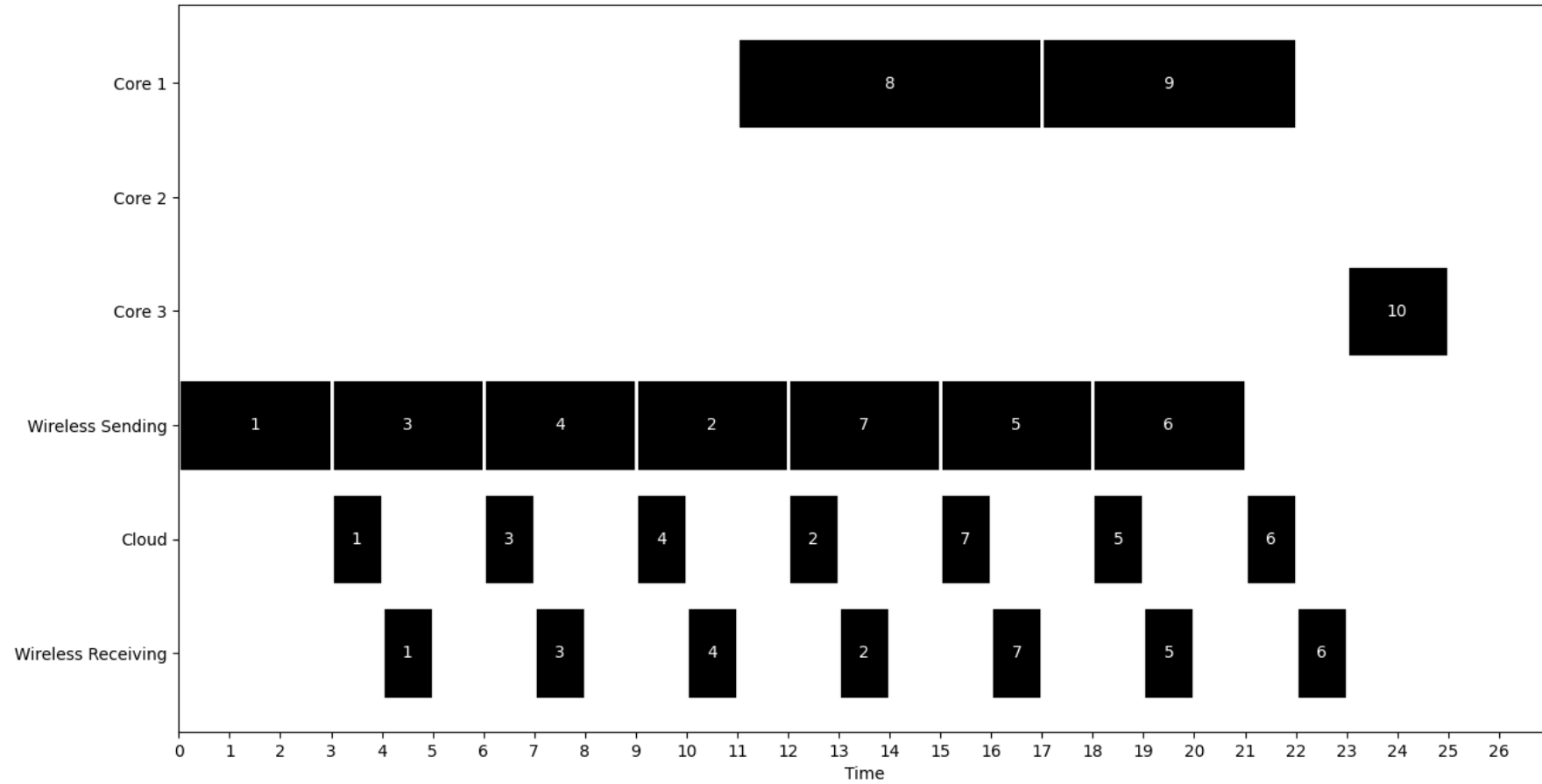cloud count = 7 (node 1,2,3,4,5,6,7)

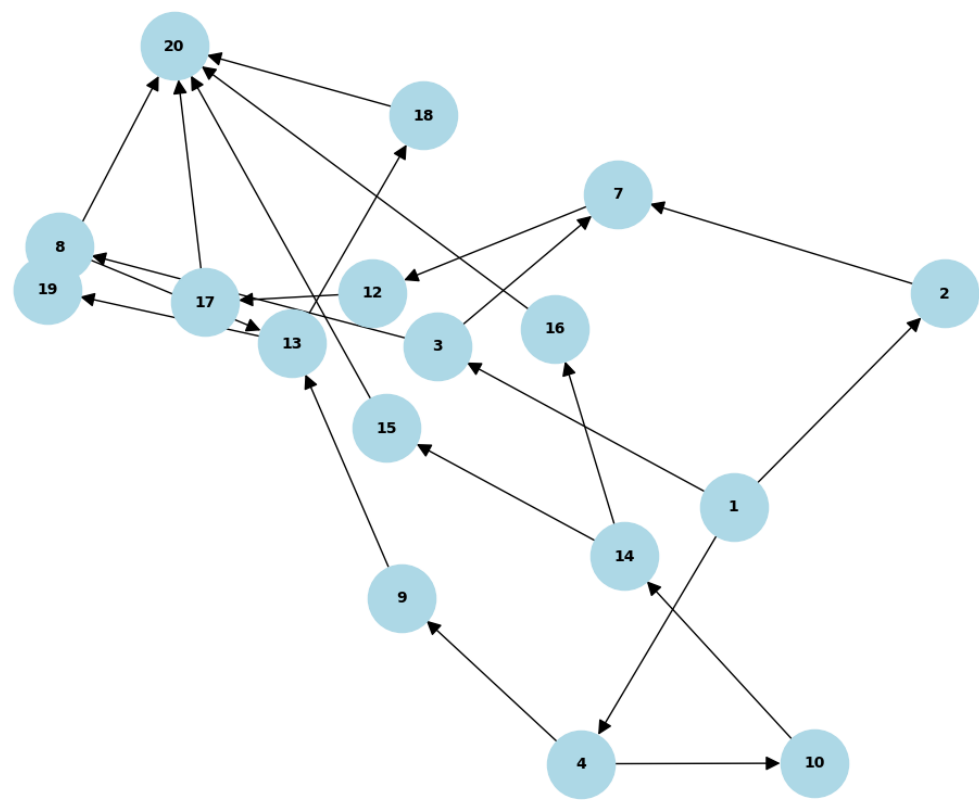e1 = 6*1 + 5*1 = 11
e2 = 0
e3 = 2*4 = 8

ecloud = 7*3*0.5 = 10.5
e_total = e1+e2+e3+ecloud = 29.5

#2 Final Results Plot

Test Case #3

Graph Representation


```
Core Processing Times Table:
Node ID   Core1    Core2    Core3
   1        9        7        5
   2        8        6        5
   3        6        5        4
   4        7        5        4
   5        5        4        2
   6        7        6        5
   7        8        5        4
   8        6        4        2
   9        9        7        3
  10        7        4        2
  11        6        5        4
  12       10        8        6
  13       12       11        9
  14       14       11        7
  15       11        9        6
  16        9        7        4
  17        7        6        3
  18        9        7        4
  19        8        6        3
  20       12        5        4


Additional Parameters Table:
 Parameter    Value
  Ws_time       3
 Cloud_time     1
  Wr_time       1
```

#3 Initial Scheduling Results

```
Node ID: 1, Assignment: Core 3, Local Start time: 0, Local Finish time: 5
Node ID: 2, Assignment: Core 1, Local Start time: 5, Local Finish time: 13
Node ID: 3, Assignment: Core 3, Local Start time: 9, Local Finish time: 13
Node ID: 4, Assignment: Cloud, Cloud Start time: 8, Cloud Finish time: 9, WS
time: 9, WR Finish time: 10
Node ID: 5, Assignment: Core 2, Local Start time: 5, Local Finish time: 9
Node ID: 6, Assignment: Core 3, Local Start time: 5, Local Finish time: 9
Node ID: 7, Assignment: Core 3, Local Start time: 15, Local Finish time: 18
Node ID: 8, Assignment: Cloud, Cloud Start time: 16, Cloud Finish time: 17, W
art time: 17, WR Finish time: 18
Node ID: 9, Assignment: Core 3, Local Start time: 13, Local Finish time: 15
Node ID: 10, Assignment: Core 2, Local Start time: 9, Local Finish time: 13
Node ID: 11, Assignment: Core 2, Local Start time: 13, Local Finish time: 16
Node ID: 12, Assignment: Cloud, Cloud Start time: 21, Cloud Finish time: 22,
tart time: 22, WR Finish time: 23
Node ID: 13, Assignment: Core 2, Local Start time: 18, Local Finish time: 21
Node ID: 14, Assignment: Core 3, Local Start time: 18, Local Finish time: 22
Node ID: 15, Assignment: Core 3, Local Start time: 22, Local Finish time: 24
Node ID: 16, Assignment: Core 1, Local Start time: 16, Local Finish time: 25
Node ID: 17, Assignment: Core 2, Local Start time: 23, Local Finish time: 26
Node ID: 18, Assignment: Core 3, Local Start time: 24, Local Finish time: 26
Node ID: 19, Assignment: Core 3, Local Start time: 26, Local Finish time: 29
Node ID: 20, Assignment: Core 3, Local Start time: 29, Local Finish time: 33
--------------------------------------------------------------------
iter: 0
initial time: 33
initial energy: 187.5
--------------------------------------------------------------------
```
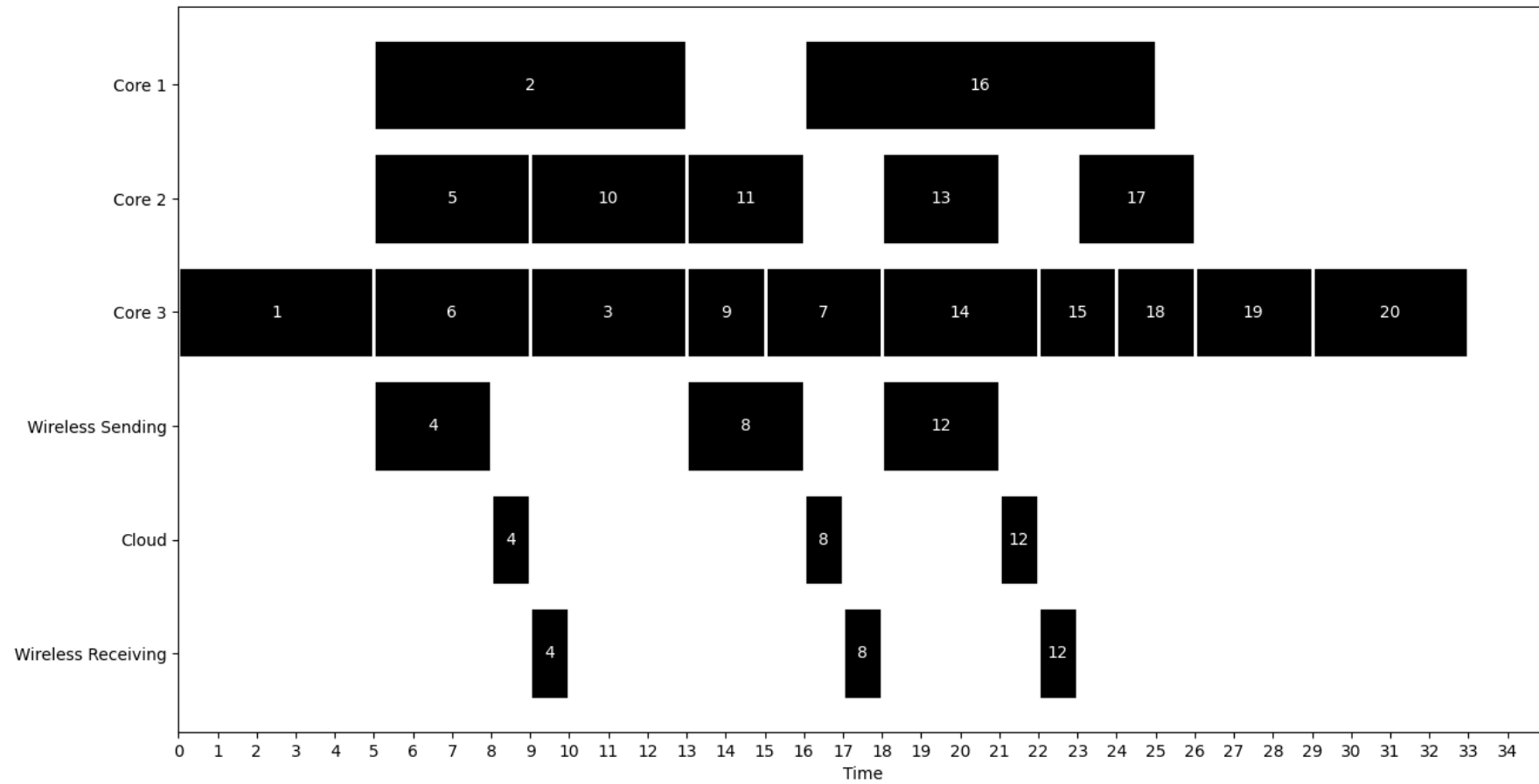
energy = power * time
e1 = 8*1 + 9*1 = 17
e2 = 4*2 + 4*2 + 3*2 + 3*2 + 3*2 = 34
e3 = 4(5+4+4+3+2+4+2+2+3+4) = 132

ecloud = 3*3*0.5 = 4.5
e_total = e1+e2+e3+ecloud = 187

#3 Initial Plot

#3 Final Scheduling Results

```
final sequence:
[5 ]
[11 15 13 17 ]
[]
[1 4 2 6 3 10 9 7 16 14 8 12 19 18 20 ]

initial time: 33
initial energy: 187.5

final time: 47
final energy: 53.5

c:\Users\Lawrence\source\repos\idk\idk\x64\Debug\idk.exe (process 23412) exited with code 0 (0x0).
Press any key to close this window . . .
```

core 1 count = 1 (node 5)
core 2 count = 4 (node 11,13,15,17)
core 3 count = 0

cloud count = 15 (node 1,2,3,4,6,7,8,9,10,12,14,16,18,19,20)

$e1 = 5*1 = 5$
$e2 = 2(3+3+4+3) = 26$
$e3 = 0$

$ecloud = 15*3*0.5 = 22.5$
$e\_total = e1+e2+e3+ecloud = 53.5$

#3 Final Results Plot
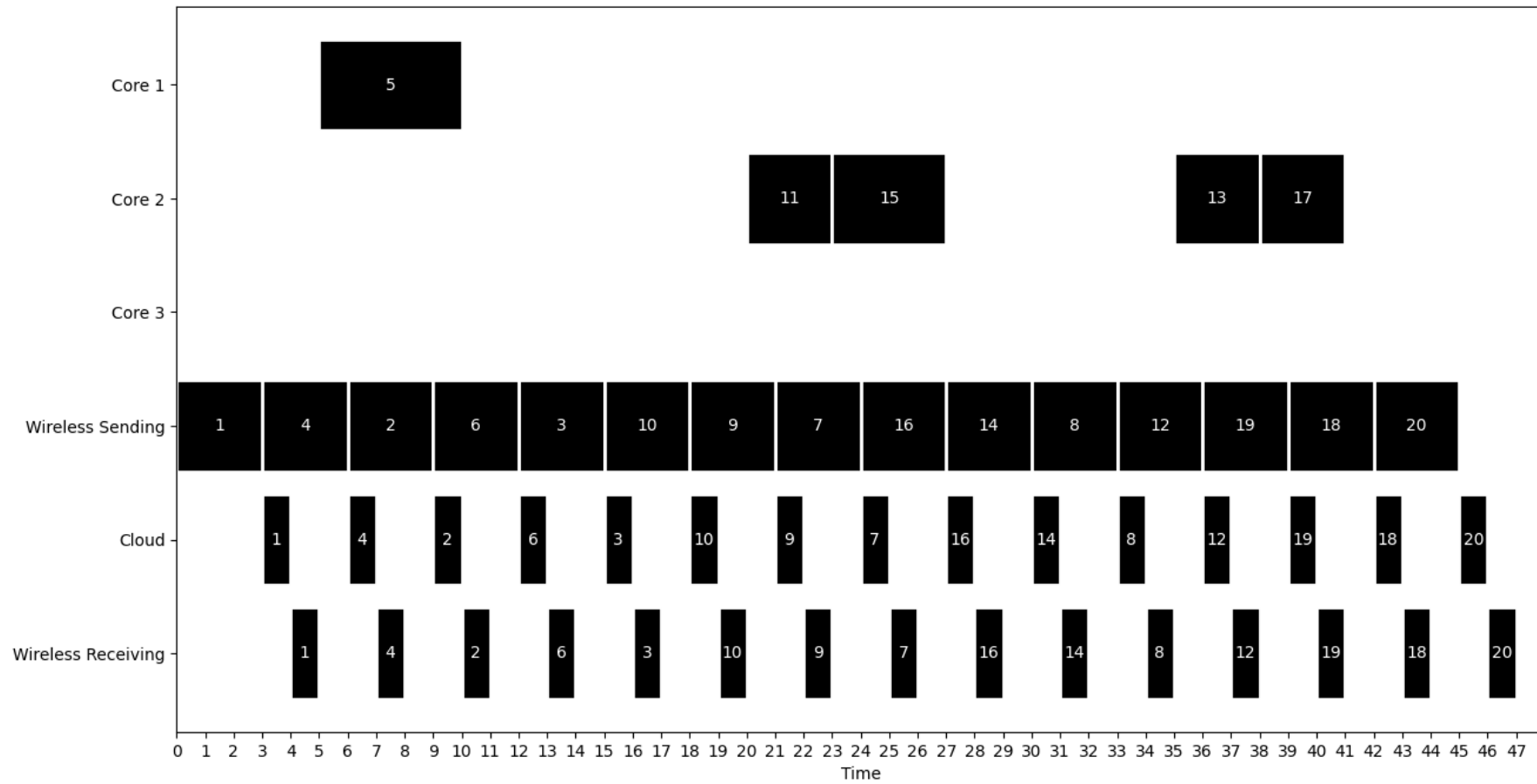
Test Case #4

Graph Representation
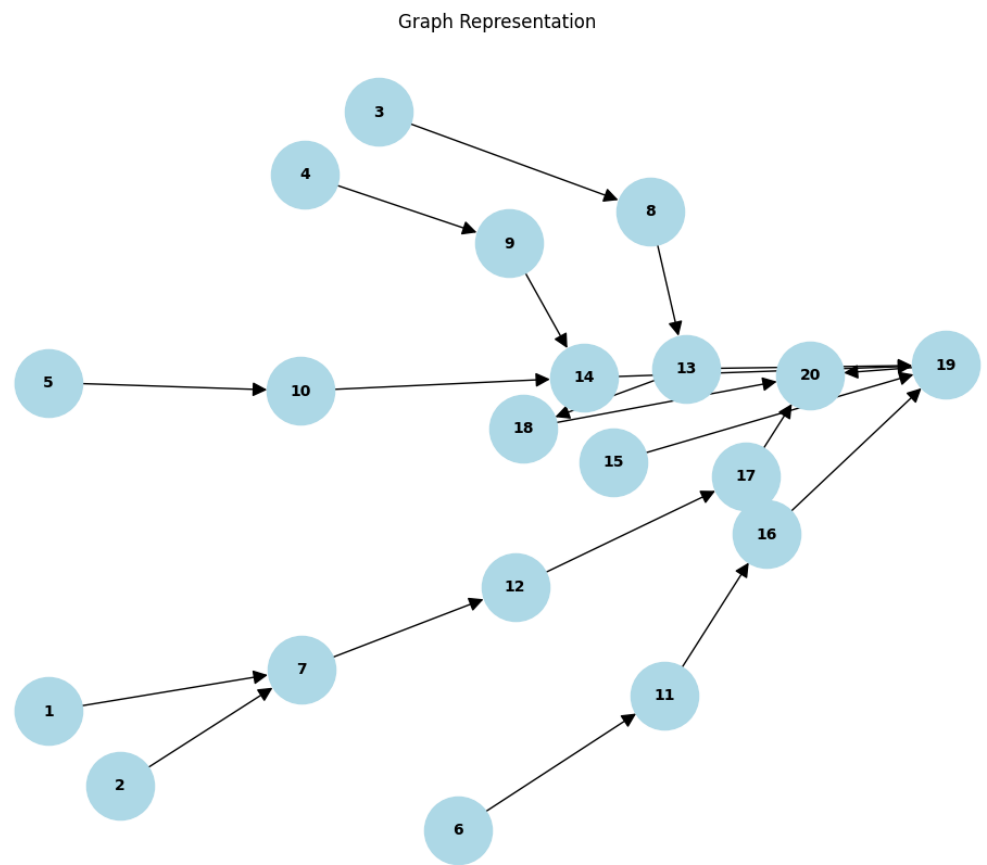
```
Core Processing Times Table:
Node ID    Core1    Core2    Core3
   1         9        7        5
   2         8        6        5
   3         6        5        4
   4         7        5        4
   5         5        4        2
   6         7        6        5
   7         7        6        5
   8         6        4        2
   9         5        5        3
  10         4        2        2
  11         5        3        4
  12        10        8        6
  13        12       11        9
  14        12       11        9
  15        11       10        6
  16         9        7        4
  17         7        6        3
  18         9        7        4
  19         9        7        5
  20        12        5        4

Additional Parameters Table:
  Parameter    Value
   Ws_time       3
 Cloud_time      1
   Wr_time       1
```

#4 Initial Scheduling Results

```
Node ID: 1, Assignment: Cloud, Cloud Start time: 6, Cloud Finish time: 7, WS Start time: 3, WS Finish time: 6,
time: 7, WR Finish time: 8
Node ID: 2, Assignment: Cloud, Cloud Start time: 9, Cloud Finish time: 10, WS Start time: 6, WS Finish time: 9,
 time: 10, WR Finish time: 11
Node ID: 3, Assignment: Core 3, Local Start time: 7, Local Finish time: 11
Node ID: 4, Assignment: Core 3, Local Start time: 4, Local Finish time: 7
Node ID: 5, Assignment: Cloud, Cloud Start time: 3, Cloud Finish time: 4, WS Start time: 0, WS Finish time: 3,
time: 4, WR Finish time: 5
Node ID: 6, Assignment: Core 3, Local Start time: 0, Local Finish time: 4
Node ID: 7, Assignment: Core 3, Local Start time: 13, Local Finish time: 16
Node ID: 8, Assignment: Cloud, Cloud Start time: 14, Cloud Finish time: 15, WS Start time: 11, WS Finish time:
art time: 15, WR Finish time: 16
Node ID: 9, Assignment: Core 3, Local Start time: 11, Local Finish time: 13
Node ID: 10, Assignment: Core 2, Local Start time: 9, Local Finish time: 13
Node ID: 11, Assignment: Core 2, Local Start time: 13, Local Finish time: 16
Node ID: 12, Assignment: Cloud, Cloud Start time: 19, Cloud Finish time: 20, WS Start time: 16, WS Finish time:
tart time: 20, WR Finish time: 21
Node ID: 13, Assignment: Core 2, Local Start time: 16, Local Finish time: 19
Node ID: 14, Assignment: Core 3, Local Start time: 16, Local Finish time: 20
Node ID: 15, Assignment: Core 2, Local Start time: 19, Local Finish time: 23
Node ID: 16, Assignment: Core 3, Local Start time: 20, Local Finish time: 23
Node ID: 17, Assignment: Cloud, Cloud Start time: 24, Cloud Finish time: 25, WS Start time: 21, WS Finish time:
tart time: 25, WR Finish time: 26
Node ID: 18, Assignment: Core 3, Local Start time: 23, Local Finish time: 25
Node ID: 19, Assignment: Core 2, Local Start time: 23, Local Finish time: 28
Node ID: 20, Assignment: Core 3, Local Start time: 28, Local Finish time: 32
-----------------------------------------------------------------------------
iter: 0
initial time: 32
initial energy: 163
```

core1 =1, core2 = 2, core3 = 4, cloud =0.5
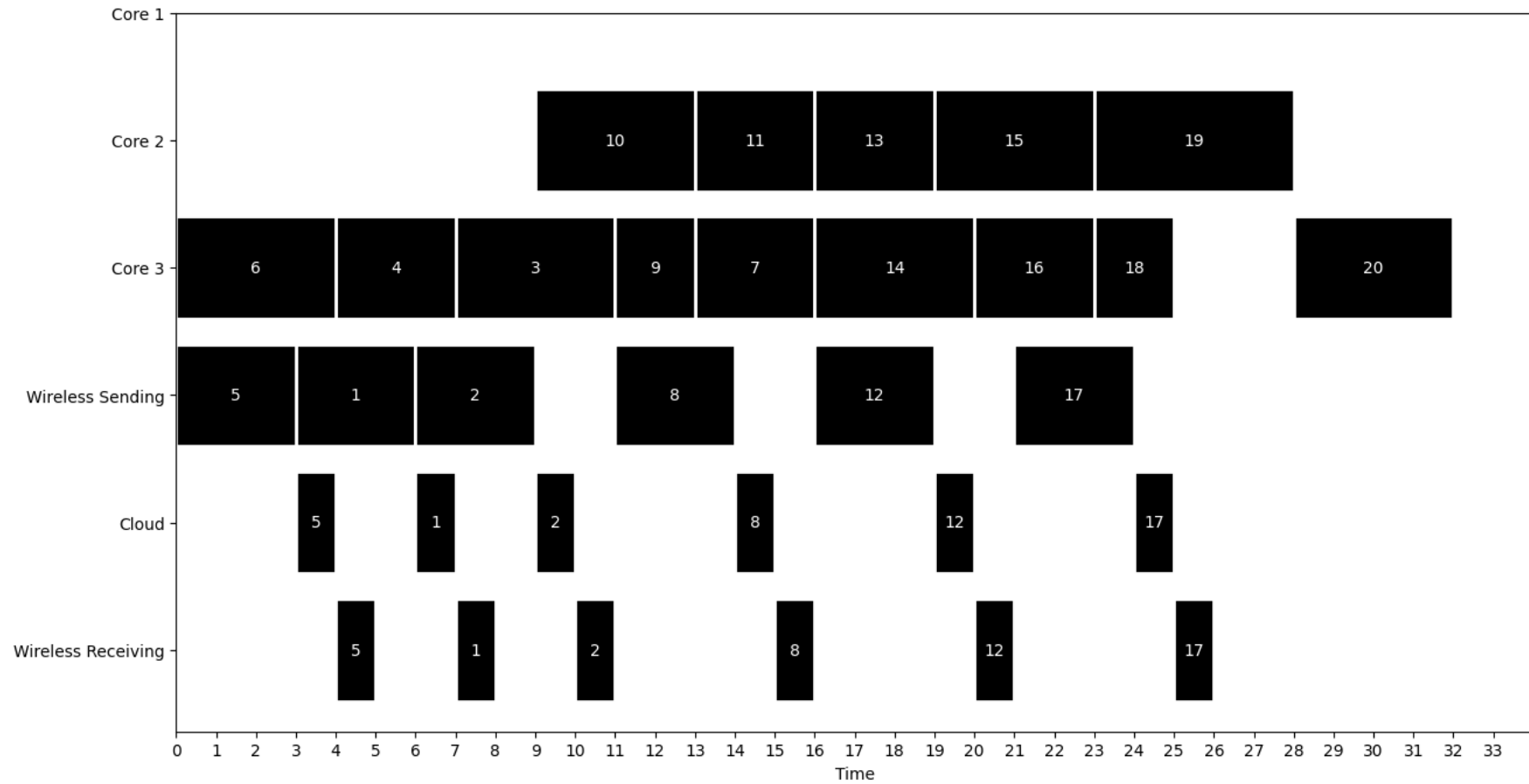
energy = power * time
e1 = 0
e2 = 2(4+3+3+4+5) = 44
e3 = 4(4+3+4+3+2+4+3+2+4) = 116

ecloud = 6*3*0.5
e_total = e1+e2+e3+ecloud = 163

#4 Initial Results Plot

#4 Final Scheduling Results

```
final sequence:
[6 3 9 ]
[11 13 ]
[]
[4 5 1 2 10 8 7 15 14 16 18 12 19 17 20 ]

initial time: 32
initial energy: 163

final time: 47
final energy: 52.5

C:\Users\Lawrence\source\repos\idk\idk\x64\Debug\idk.exe (process 19804) exited with code 0 (0x0).
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automati
le when debugging stops.
Press any key to close this window . . .
```

core 1 count = 3 (node 3,6,9)
core 2 count = 2 (node 11,13
core 3 count = 0
cloud count = 15 (node
1,2,4,5,7,8,10,12,14,15,16,17,18,19,20)

$e1 = 1(6+7+5) = 18$
$e2 = 2(3+3) = 12$
$e3 = 0$
$ecloud = 15*3*0.5 = 22.5$
$e\_total = e1+e2+e3+ecloud = 52.5$

#4 Final Results Plot
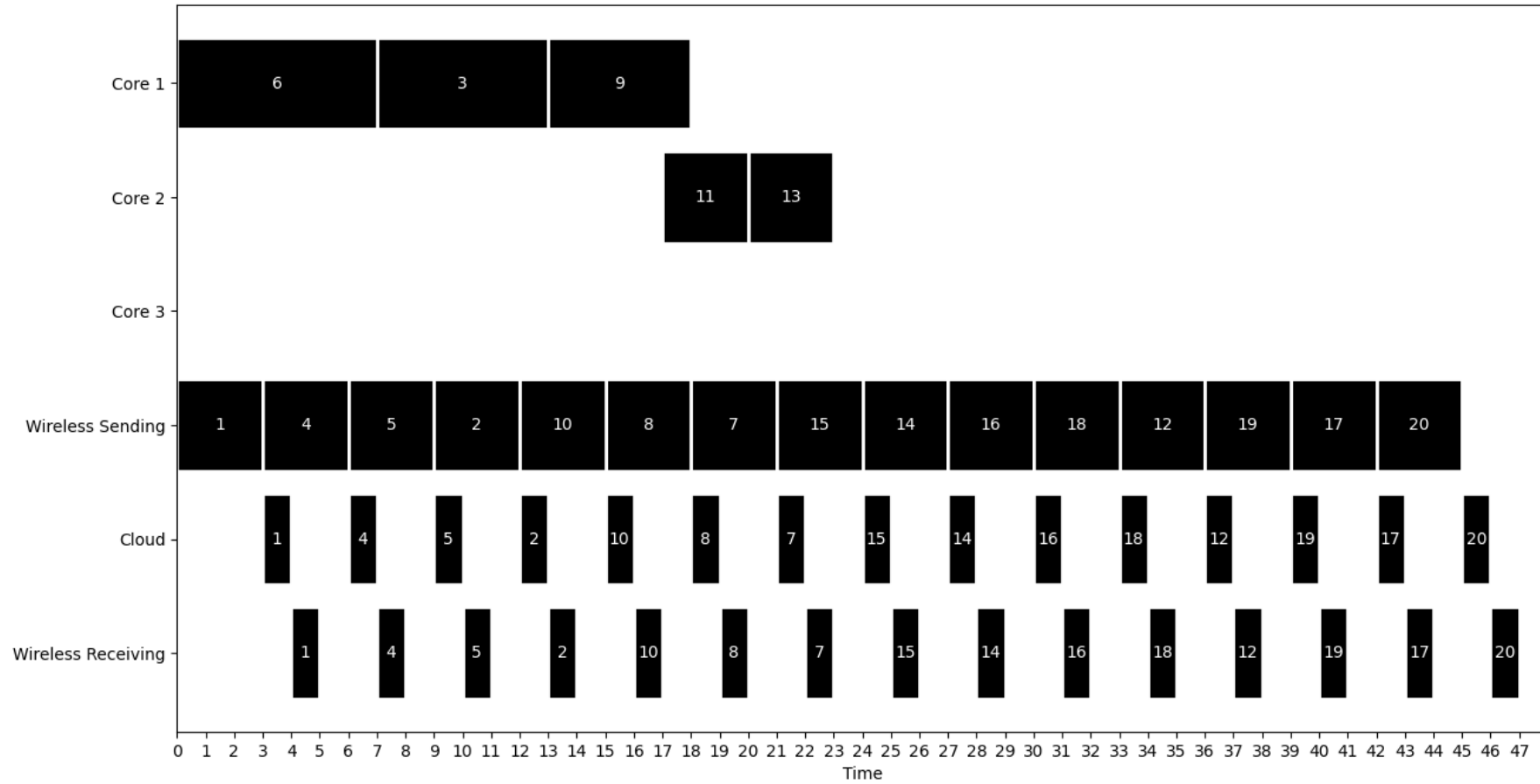
Test Case #5
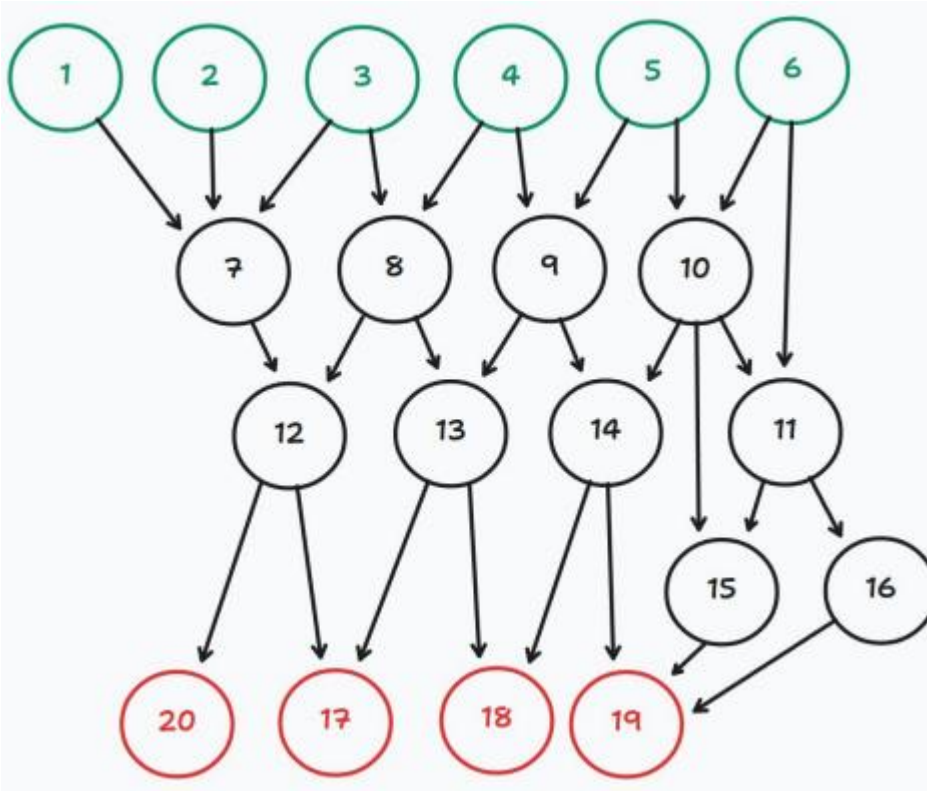
Node ID	Core1	Core2	Core3
1	9	7	5
2	8	6	5
3	6	5	4
4	7	5	5
5	5	4	2
6	6	5	3
7	7	6	5
8	6	4	3
9	5	5	3
10	4	2	2
11	5	3	3
12	8	8	6
13	12	11	9
14	11	11	9
15	11	10	6
16	9	7	4
17	7	6	3
18	9	7	4
19	7	5	4
20	12	5	4

Additional Parameters Table:

Parameter	Value
Ws_time	3
Cloud_time	1
Wr_time	1

#5 Initial Scheduling Results

```
Node ID: 1, Assignment: Cloud, Cloud Start time: 6, Cloud Finish time: 7, WS
time: 7, WR Finish time: 8
Node ID: 2, Assignment: Cloud, Cloud Start time: 9, Cloud Finish time: 10, WS
 time: 10, WR Finish time: 11
Node ID: 3, Assignment: Core 3, Local Start time: 7, Local Finish time: 11
Node ID: 4, Assignment: Core 3, Local Start time: 4, Local Finish time: 7
Node ID: 5, Assignment: Cloud, Cloud Start time: 3, Cloud Finish time: 4, WS
time: 4, WR Finish time: 5
Node ID: 6, Assignment: Core 3, Local Start time: 0, Local Finish time: 4
Node ID: 7, Assignment: Core 3, Local Start time: 13, Local Finish time: 16
Node ID: 8, Assignment: Cloud, Cloud Start time: 14, Cloud Finish time: 15, W
art time: 15, WR Finish time: 16
Node ID: 9, Assignment: Core 3, Local Start time: 11, Local Finish time: 13
Node ID: 10, Assignment: Core 2, Local Start time: 9, Local Finish time: 13
Node ID: 11, Assignment: Core 2, Local Start time: 13, Local Finish time: 16
Node ID: 12, Assignment: Cloud, Cloud Start time: 19, Cloud Finish time: 20,
tart time: 20, WR Finish time: 21
Node ID: 13, Assignment: Core 2, Local Start time: 16, Local Finish time: 19
Node ID: 14, Assignment: Core 3, Local Start time: 16, Local Finish time: 20
Node ID: 15, Assignment: Core 2, Local Start time: 19, Local Finish time: 23
Node ID: 16, Assignment: Core 3, Local Start time: 20, Local Finish time: 23
Node ID: 17, Assignment: Core 3, Local Start time: 25, Local Finish time: 28
Node ID: 18, Assignment: Core 3, Local Start time: 23, Local Finish time: 25
Node ID: 19, Assignment: Core 2, Local Start time: 23, Local Finish time: 28
Node ID: 20, Assignment: Cloud, Cloud Start time: 24, Cloud Finish time: 25,
tart time: 25, WR Finish time: 26
--------------------------------------------------------------
iter: 0
initial time: 26
initial energy: 159
```

power for each device:
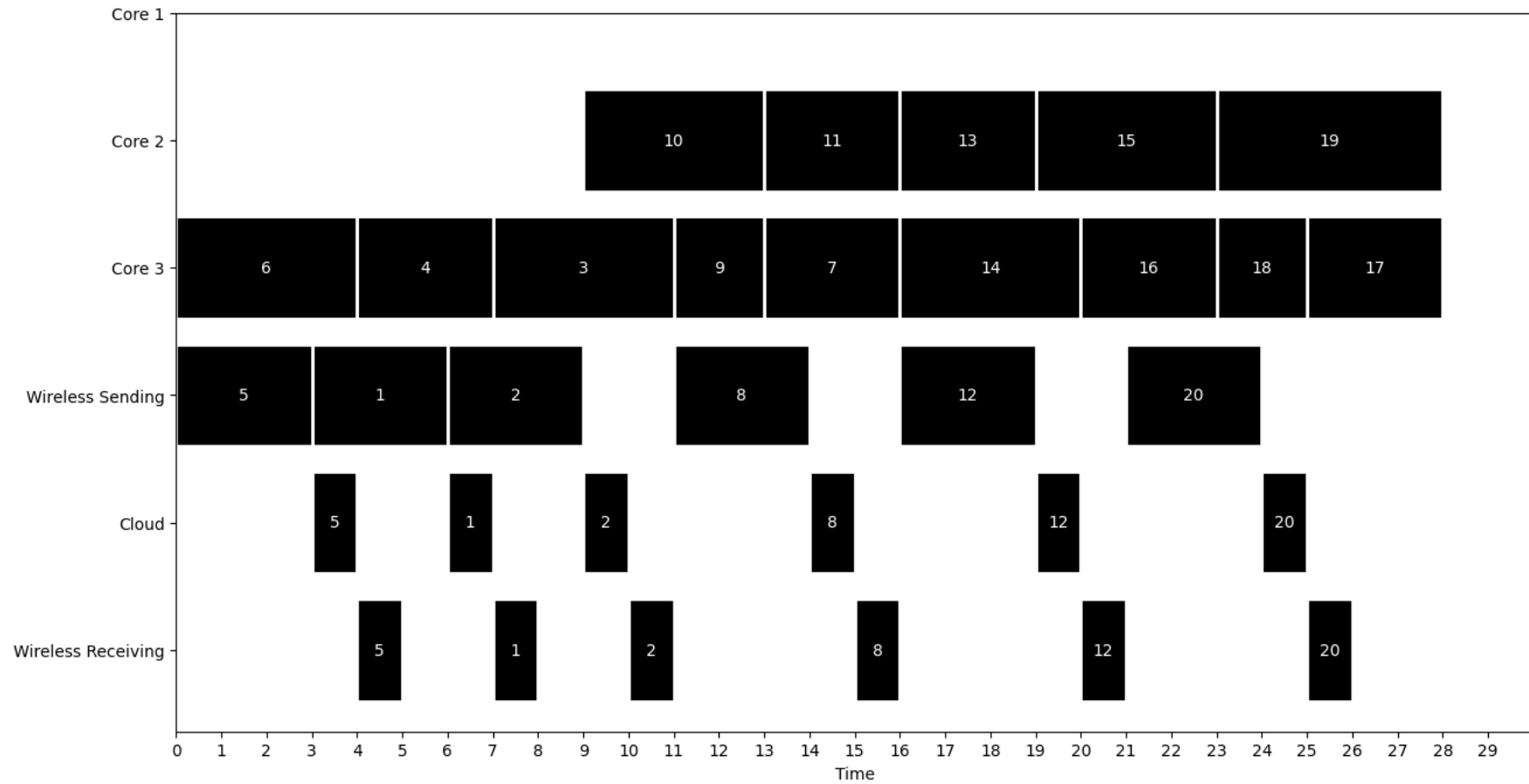core1 =1, core2 = 2, core3 = 4, cloud =0.5
energy = power * time

e1 = 0
e2 = 2(4+3+3+4+5) = 38
e3 = 4(4+3+4+3+2+4+3+3+2) = 112

ecloud = 6*3*0.5 =9
e_total = e1+e2+e3+ecloud = 24

#5 Initial Plot Results

#5 Final Scheduling Results

core 1 count = 5 (node 4,6,9,10,14)

core 2 count = 2 (node 11,13)

core 3 count = 1 (node 7)

cloud count = 12 (node
1,2,3,5,8,12,15,16,17,18,19,20)
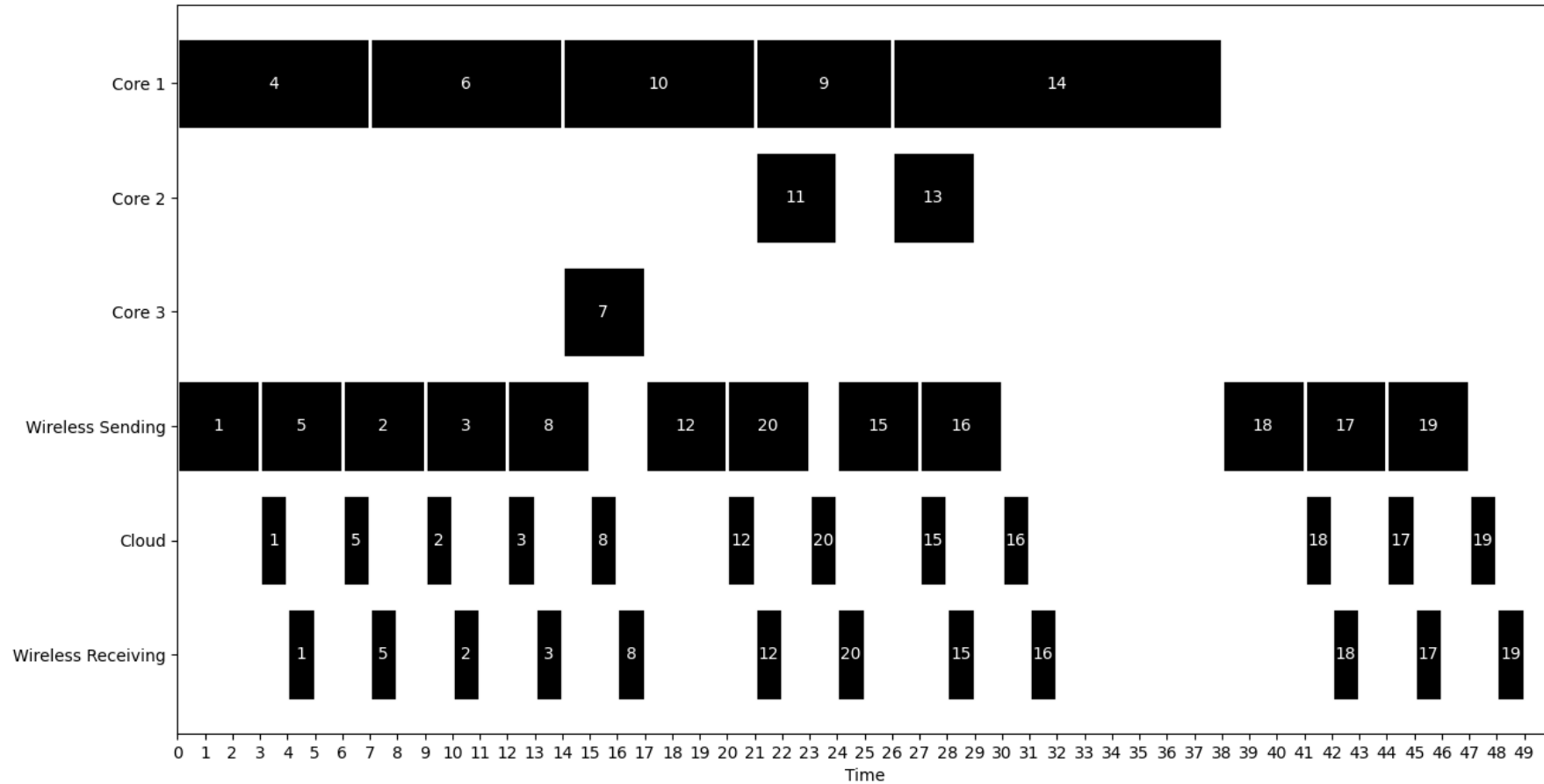
$e1 = 1(7+7+5+7+12) = 38$

$e2 = 2(3+3)= 12$

$e3 = 4(3)= 12$

$ecloud = 12*3*0.5= 18$

$e\_total = e1+e2+e3+ecloud = 80$

#5 Final Plot Results

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

[2] Cormen, Thomas, Charles Leiserson, Ronald Rivest, and Clifford Stein. Introduction to Algorithms. 3rd ed. MIT Press, 2009. ISBN: 9780262033848.