PARALLEL COMPUTING OF AES ENCRYPTION ALGORITHM

A PROJECT REPORT

Submitted by

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Course Code: CSE4001

Course Title: PARALLEL AND DISTRIBUTED COMPUTING

Under the guidance of

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Associate Professor, SCOPE,

VIT , Vellore.

Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

April, 2022

OUTPUT AND PERFORMANCE ANALYSIS

6.1.3. Highly coarse grained approach

Parallel :


```
neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fin
alImplementation/parallel_code$ g++ -fopenmp 01_highly_coarse_grained_parallel.cpp
neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fin
alImplementation/parallel_code$ ./a.out
Enter the message to encrypt: Sample text for Roma : the novel of ancient Rome / Steven Saylor
.Bibliographic record and links to related information available from the Library of Congress
catalogCopyrighted sample text provided by the publisher and used with permission. May be inco
mplete or contain other coding.CounterChapter OneA Stop on the Salt Route1000 B.C.As they roun
ded a bend in the path that ran beside the river, Lara recognized the silhouette of a fig tree
 atop a nearby hill. The weather was hot and the days were long. The fig tree was in full leaf
, but not yet bearing fruit.Soon Lara spotted other landmarks—an outcropping of limestone besi
de the path that had a silhouette like a man's face, a marshy spot beside the river where the
waterfowl were easily startled, a tall tree that looked like a man with his arms upraised. The
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 spot to make camp. They would sleep on the island tonight.Lara had been back and forth along
the river path many times in her short life. Her people had not created the path—it had always
 been there, like the river—but their deerskin-shod feet and the wooden wheels of their handca
rts kept the path well worn. Lara's people were salt traders, and their livelihood took them o
n a continual journey.At the mouth of the river, the little group of half a dozen intermingled
 families gathered salt from the great salt beds beside the sea. They groomed and sifted the s
alt and loaded it into handcarts. When the carts were full, most of the group would stay behin
d, taking shelter amid rocks and simple lean-tos, while a band of fifteen or so of the heartie
r members set out on the path that ran alongside the river.With their precious cargo of salt,
the travelers crossed the coastal lowlands and traveled toward the mountains. But Lara's peopl
e never reached the mountaintops; they traveled only as far as the foothills.
Sample text for Roma : the novel of ancient Rome / Steven Saylor.Bibliographic record and link
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 provided by the publisher and used with permission. May be incomplete or contain other coding
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tal lowlands and traveled toward the mountains. But Lara's people never reached the mountainto
ps; they traveled only as far as the foothills.
padded msg length : 1952
thread 3 is encrypting a block of 16bytes
```

```
neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fina...

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...        neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...

thread 3 is encrypting a block of 16bytes
thread 1 is encrypting a block of 16bytes
thread 2 is encrypting a block of 16bytes
thread 0 is encrypting a block of 16bytes
Time taken to encrypt  :0.000537807
Encrypted message in hex:
f7 f4 9f 7c 9c eb 41 6c f5 b3 d9 d6 50 87 93 38 34 99 34 1a 30 4d bd 1c 3a 85 a2 2f 38 98 83 6
f 9d e5 f5 3d 50 51 7d ef a8 7e 4b d2 16 3b 95 fc f 72 df 9 5 fd e7 9e dd 4 23 a1 24 12 b3 c1
3d 67 f4 fb 1c 2d 3b e2 90 4d 95 9e 92 2a 7a 4f 6f 8b 9a 72 32 30 60 37 10 db 35 56 89 85 f2 1
a 98 c2 b6 47 37 9d 5a 8e e2 7 b6 26 a 23 3 27 e4 e0 60 ed 78 ca fc d1 d f3 51 9d 36 5a 49 d6
41 5 e6 13 a6 fb 95 65 6a cd d5 e9 35 8a 7b ba 9b 5d 14 ca 11 e9 29 e9 f1 92 49 de af 67 68 b0
 cd be 2a 43 f7 dd d8 2 85 28 69 7 82 3a 75 c6 af 14 fc 7e eb 9f 83 24 86 9a 86 27 1 ac ac c7
cc da 14 a4 7c 38 5a 94 f6 dc e3 67 cf 5b 75 2c dd 91 a5 b 48 97 6d e6 7a 21 4b 5 6e b8 c4 89
5a 29 f4 55 f2 d1 f5 3 62 ee 1f f3 dd 72 c2 f6 a0 2 58 63 a1 42 2b e7 66 90 80 1c 13 57 32 42
c7 6d c6 d7 3d 72 c7 e6 de bc d8 65 be 80 a3 49 cc 55 51 a7 45 17 c8 58 14 87 11 97 dd d9 19 7
3 91 14 39 7d 9b a8 f7 77 7f 89 ed b2 d5 64 a9 55 c4 38 b1 29 56 a0 2 7b e7 df 7a b6 72 c3 63
d 53 b4 63 80 82 1c d4 9b 74 3e 9f 3d 97 b3 72 7e 8b 1e 7c bb bf 4d 57 23 81 ff 37 ae b0 6c a7
 80 6d 6f 12 5f 76 8b 93 1c 96 c8 0 6 23 94 f 25 eb 97 9b b9 9e f9 ee d1 12 77 77 4e 43 e7 c9
64 20 6 83 ab 56 6 c1 43 9f 44 1 a1 e5 a6 ae 41 98 78 31 79 21 f ff 9d d 4f 97 3f 6c 34 b2 3b
f6 9f df fb 6f 1 d 7b 5 8d 5c 79 b d5 50 6f 70 4d c3 ad 8 5f 2d 5f a8 3b 13 22 79 99 94 15 a8
c8 92 80 84 79 ba 5f c8 a f9 67 85 d2 72 94 30 4 a 79 e8 3f 9f b8 69 13 e0 62 f a0 fd dd eb d7
 23 8f ea c2 d9 71 a1 77 d3 31 92 7c a8 b6 e6 f5 d3 31 d9 fe 7b e7 48 a8 7d 9a 6b 55 98 e4 9b
7b ff dc 74 61 84 a9 59 25 6e c3 47 df 5b d5 9e cf c5 aa b6 a bc aa 42 64 c7 46 67 f8 1e 1c 4f
 47 33 ce 6c 14 28 a1 4 22 3f 2b af 3f 70 38 ca de a4 b4 4c 44 a7 ff 96 87 13 a3 42 2f 12 66 7
1 73 3a 8 ac b9 ce 32 fe e4 6c c1 75 f8 10 77 8a d8 24 ef fb 9a 71 10 40 d d7 8e ee b2 bd b6 e
0 d1 79 43 65 7c b bf 66 42 95 97 5f 22 9 73 50 f4 8b c4 fd f6 e6 21 8f dd c6 9 eb f3 fd 3e 4
66 1c df c6 60 fa 30 11 48 5b 42 aa d8 a8 91 1c bc df 4d 4b db 3e 5c 95 30 b7 41 3d 51 ab cd f
a 18 11 b1 eb 51 20 ea 5f 22 37 c3 ac 18 f5 9e ad 8 dd ea 55 32 46 22 ba 5b 6e 43 6d 6c 1f a5
8 cb d2 f7 3d 72 5c a0 5d 67 37 4c 92 7 1c cb 7b 4b ac 20 7b 5e 5d 67 dc e8 f2 fd 2f 72 a 2a 4
5 59 48 d3 6e 72 d3 5e b2 14 a4 f6 b0 d0 6b ba 23 23 5 ca e6 11 d7 a 7d c5 ac a0 7b fc 8 d 5e
73 9b d7 a9 ce 1 da eb 23 c6 df ae 79 4e 18 41 ec a6 5e 2b 51 6 44 4b f d4 8e f9 5b 16 ac b2 1
c a a5 9e c8 5a 22 fa ec 93 68 d7 b1 91 9 8a 3a ff 42 da 5e 88 2 44 4e 5e 40 f8 9 8d b5 b9 31
c4 d0 3e b5 aa 6c 9d 83 e9 b0 a6 6f 35 da ce 2e 4c 60 9c 59 8e 3 7f 70 9e 1c 12 f7 87 e0 f8 d6
 42 1e a4 b1 50 f 37 8a 7b 99 27 91 3c 35 e6 d8 13 ad 95 38 c0 1 1a 82 51 2d 84 58 d1 5c 0 e1
4c e1 1b 80 1d 54 4c 2c 81 9b 13 52 a7 9f 93 81 d2 99 2b fd 24 79 72 d3 53 be 47 15 d2 91 13 e
2 39 1e 32 c0 c4 75 82 a4 c8 d6 a6 5c a b2 6c c6 f5 9f 71 87 98 f0 5e 99 bd a5 6d f9 26 34 73
f c0 80 ce 73 d8 90 15 4f 3a 4e bd 5f 3d d8 d7 f6 66 e8 0 a6 45 ad 1 d7 6f d8 4 6f 16 6d f2 b0
 a6 1f 37 81 25 3f f0 e6 e7 a7 e2 bb 64 2c b5 72 bc f3 f7 4f 28 a8 e9 52 13 27 18 8f cf 5e 5d
b1 32 3f 8e 46 7e 6a 9a d 65 10 84 21 68 8a 6f 1d 61 2 23 70 ae ea 6c f f0 d2 b9 a0 7a 6a 24 d
a be c2 99 5a eb e0 a4 ce 20 77 4e 2c b0 b1 8e 8d ed 7f 56 31 1b 5 3e 3c 6a 85 6e a7 97 fc f 4
9 99 c2 ae 7e 1a d 6f 1d 24 ce e5 de c5 20 57 5d 48 11 2b 27 84 7b 90 e9 a8 5c f0 b8 e0 35 f3
b5 d0 bf 6c 4f 4c c1 fd d1 e4 aa 3c 61 5 ba a8 b 73 ed 8c e5 bb b0 22 64 6d 74 ec 3c a4 70 29
8e 3 7b 90 40 af 5b 1e 91 36 e1 14 f0 6d 54 8d e0 3b 9 cb 3b ba 63 1 b 82 9a f1 6c c4 f6 a9 2d
 92 a3 f 8e a2 ae f2 70 8b 2d 15 7e ef 81 e 3d 25 42 44 50 18 a5 9f f9 cd 2d 94 41 21 97 40 a2
 15 3c c9 16 35 5c ea ff 68 6a 56 54 63 33 7e 4b 21 f9 8a e2 3a f6 1d 75 8b 89 8a 77 a5 eb ca
5b ab 3d 3a 3d 92 18 9e a1 d8 52 71 18 3d f8 9d 8d 9a a7 48 66 d3 a0 59 55 7b e1 96 5 3c d2 7c
79 f4 6 d7 25 d 7a 2 69 f5 9f a1 a2 7c 87 5c 81 fb 2c 95 3f 34 98 c7 9f e d5 ec 64 64 28 ae e
9 b7 63 21 62 f4 4 3f 2e 9b 10 d0 cd 81 3f 18 2b 79 85 b7 ec 93 d5 42 1a c9 ce 4c d9 c3 c4 76
```

0 d1 79 43 65 7c b bf 66 42 95 97 5f 22 9 73 50 f4 8b c4 fd f6 e6 21 8f dd c6 9 eb f3 fd 3e 4
66 1c df c6 60 fa 30 11 48 5b 42 aa d8 a8 91 1c bc df 4d 4b db 3e 5c 95 30 b7 41 3d 51 ab cd f
a 18 11 b1 eb 51 20 ea 5f 22 37 c3 ac 18 f5 9e ad 8 dd ea 55 32 46 22 ba 5b 6e 43 6d 6c 1f a5
8 cb d2 f7 3d 72 5c a0 5d 67 37 4c 92 7 1c cb 7b 4b ac 20 7b 5e 5d 67 dc e8 f2 fd 2f 72 a 2a 4
5 59 48 d3 6e 72 d3 5e b2 14 a4 f6 b0 d0 6b ba 23 23 5 ca e6 11 d7 a 7d c5 ac a0 7b fc 8 d 5e
73 9b d7 a9 ce 1 da eb 23 c6 df ae 79 4e 18 41 ec a6 5e 2b 51 6 44 4b f d4 8e f9 5b 16 ac b2 1
c a a5 9e c8 5a 22 fa ec 93 68 d7 b1 91 9 8a 3a ff 42 da 5e 88 2 44 4e 5e 40 f8 9 8d b5 b9 31
c4 d0 3e b5 aa 6c 9d 83 e9 b0 a6 6f 35 da ce 2e 4c 60 9c 59 8e 3 7f 70 9e 1c 12 f7 87 e0 f8 d6
 42 1e a4 b1 50 f 37 8a 7b 99 27 91 3c 35 e6 d8 13 ad 95 38 c0 1 1a 82 51 2d 84 58 d1 5c 0 e1
4c e1 1b 80 1d 54 4c 2c 81 9b 13 52 a7 9f 93 81 d2 99 2b fd 24 79 72 d3 53 be 47 15 d2 91 13 e
2 39 1e 32 c0 c4 75 82 a4 c8 d6 a6 5c a b2 6c c6 f5 9f 71 87 98 f0 5e 99 bd a5 6d f9 26 34 73
f c0 80 ce 73 d8 90 15 4f 3a 4e bd 5f 3d d8 d7 f6 66 e8 0 a6 45 ad 1 d7 6f d8 4 6f 16 6d f2 b0
 a6 1f 37 81 25 3f f0 e6 e7 a7 e2 bb 64 2c b5 72 bc f3 f7 4f 28 a8 e9 52 13 27 18 8f cf 5e 5d
b1 32 3f 8e 46 7e 64 9a d 65 10 84 21 68 8a 6f 1d 61 2 23 70 ae ea 6c f f0 d2 b9 a0 7a 6a 24 d
a be c2 99 5a eb e0 a4 ce 20 77 4e 2c b0 b1 8e 8d ed 7f 56 31 1b 5 3e 3c 6a 85 6e a7 97 fc f 4
9 99 c2 ae 7e 1a d 6f 1d 24 ce e5 de c5 20 57 5d 48 11 2b 27 84 7b 90 e9 a8 5c f0 b8 e0 35 f3
b5 d0 bf 6c 4f 4c c1 fd d1 e4 aa 3c 61 5 ba a8 b 73 ed 8c e5 bb b0 22 64 6d 74 ec 3c a4 70 29
8e 3 7b 90 40 af 5b 1e 91 36 e1 14 f0 6d 54 8d e0 3b 9 cb 3b ba 63 1 b 82 9a f1 6c c4 f6 a9 2d
 92 a3 f 8e a2 ae f2 70 8b 2d 15 7e ef 81 e 3d 25 42 44 50 18 a5 9f f9 cd 2d 94 41 21 97 40 a2
 15 3c c9 16 35 5c ea ff 68 6a 56 54 63 33 7e 4b 21 f9 8a e2 3a f6 1d 75 8b 89 8a 77 a5 eb ca
5b ab 3d 3a 3d 92 18 9e a1 d8 52 71 18 3d f8 9d 8d 9a a7 48 66 d3 a0 59 55 7b e1 96 5 3c d2 7c
 79 f4 6 d7 25 d 7a 2 69 f5 9f a1 a2 7c 87 5c 81 fb 2c 95 3f 34 98 c7 9f e d5 ec 64 64 28 ae e
9 b7 63 21 62 f4 4 3f 2e 9b 10 d0 cd 81 3f 18 2b 79 85 b7 ec 93 d5 42 1a c9 ce 4c d9 c3 c4 76
3d 60 ed 9 90 57 ef 9f 0 5a c2 89 5b b5 f5 1f 10 66 5a 2f 43 df 69 f4 94 cd 2a 8 de 97 74 e0 9
9 2a 9e 9c b2 b5 f4 1d f1 80 bf 8d 2f a0 e1 c0 f5 21 dc 8e 33 26 17 56 78 7f a8 2 95 a8 7e 28
83 96 ae 73 1a a2 f0 18 ec 7d 28 df 4b 9f 44 82 69 2a b7 6b 31 98 44 66 24 12 1f 89 2c 1b 3f 5
4 93 2c 28 6e 3 41 b4 19 fc e2 cd 2f db 8b b5 c0 17 e8 c5 31 e8 56 e6 7a e5 71 f2 f6 46 28 56
1b 57 8a a4 f6 1d 96 58 f2 e 68 fa 1b ce 57 a5 83 ba 7b bf 33 de 7a 50 d9 db fe e 0 4 9d 8a d5
 28 76 af 27 c5 20 72 3d 66 8d e 92 40 1f 4c 43 72 fa 90 b2 e7 3e 96 16 74 44 c2 92 be 35 c4 2
9 a5 a2 18 47 4a 43 4c 11 a7 c af 27 bb 6f 1b b8 54 a0 82 60 76 96 f5 2f 68 e6 91 df f9 9f 77
1e ed db 7b 7b 66 5e 2e 35 f0 f0 5f 22 8a 42 e6 d1 26 75 e 8e 44 1 e4 26 5a b e3 31 4f 3b e dd
 d6 7d f8 2d 19 e1 b 1f 3 e2 8d cf 47 ba e9 96 2b 92 b 51 59 b1 2c 31 e1 db c 29 a7 e8 6 a7 c6
 bc 2c aa c5 dc 79 ad f3 e0 32 52 4b c6 21 8e 25 4e 1a 61 e5 ef 66 f9 86 ec 93 df e9 cc f9 a6
b0 c0 76 90 41 b0 e0 45 c9 62 60 2a d9 c9 80 54 fb d0 3c 67 25 c2 bc 43 90 f3 c c1 b0 b3 39 f6
 47 c8 b9 b7 c9 3a 46 e5 69 8f 2d 2f 97 4d a3 49 e1 1f e2 4f 22 14 d3 b6 95 dc b1 b1 9 ab b2 7
0 ea 18 b7 a3 7f 39 57 8a b1 70 65 d0 43 82 76 8 2c 7b 9a b6 6f 1b 3 6d 48 bd bf 4c 5f 9a 69 9
 ad 69 36 ae 87 de f4 1 16 c 21 f1 2c 93 fc cf cd 8b e1 59 13 15 ea 4a c1 35 17 2c 44 4f 81 e7
 50 6b f6 9f bc 41 b9 a6 28 14 c0 db d7 18 b6 2 a2 ab 95 66 6c ed 7 3f 8d 2c 40 c0 7f c0 3 38
5 f0 11 4f 92 a8 ed 14 bb 16 e6 b1 74 ab 9d f0 62 a6 16 cb e bd 54 44 3c 4f 70 79 2f 4e 9c ab
34 76 3d 4c 78 84 40 f0 57 5b d4 b3 ff 68 d3 d7 9a 85 ed 3a d6 1f 16 88 df 5d 15 44 85 74 66 2
d 7a 1d e7 27 8e bb ca a7 8d 89 ff f1 44 62 9c cb ae d6 94 26 49 26 3d 9f 25 bb cd b0 92 4 69
91 dc 33 11 3d 35 21 70 2 8a 27 20 72 ee ef ba 82 6a 6e 8c 38 2d 6 b0 e3 ba c6 25 b7 8e 6a 66
Time taken by parallel highly coarse grained parallel: 0.001536s
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/finalImplementation/parallel_code$ ./a.out^C
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/finalImplementation/parallel_code$

Serial :

neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/finalImplementation/serial_code$ ./a.out

Enter the message to encrypt: Sample text for Roma : the novel of ancient Rome / Steven Saylor.Bibliographic record and links to related information available from the Library of Congress catalogCopyrighted sample text provided by the publisher and used with permission. May be incomplete or contain other coding.CounterChapter OneA Stop on the Salt Route1000 B.C.As they rounded a bend in the path that ran beside the river, Lara recognized the silhouette of a fig tree atop a nearby hill. The weather was hot and the days were long. The fig tree was in full leaf, but not yet bearing fruit.Soon Lara spotted other landmarks—an outcropping of limestone beside the path that had a silhouette like a man's face, a marshy spot beside the river where the waterfowl were easily startled, a tall tree that looked like a man with his arms upraised. They were drawing near to the place where there was an island in the river. The island was a good spot to make camp. They would sleep on the island tonight.Lara had been back and forth along the river path many times in her short life. Her people had not created the path—it had always been there, like the river—but their deerskin-shod feet and the wooden wheels of their handcarts kept the path well worn. Lara's people were salt traders, and their livelihood took them on a continual journey.At the mouth of the river, the little group of half a dozen intermingled families gathered salt from the great salt beds beside the sea. They groomed and sifted the salt and loaded it into handcarts. When the carts were full, most of the group would stay behind, taking shelter amid rocks and simple lean-tos, while a band of fifteen or so of the heartier members set out on the path that ran alongside the river.With their precious cargo of salt, the travelers crossed the coastal lowlands and traveled toward the mountains. But Lara's people never reached the mountaintops; they traveled only as far as the foothills.

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padded msg length : 1952
Time taken to encrypt (serial) :0.00103126
Encrypted message in hex:
81 b7 40 e4 1c df 35 27 4 ab de f5 93 a5 70 9b ab 2e 9b 0 3e 2c 2a 1a b8 6e 4d d 50 90 57 a6 8

c 1a a4 2f 32 88 ce 72 54 49 90 18 e4 68 e9 0 70 aa d0 4f c0 ae be 3e 73 d 36 dc 8a e1 85 d 6c
 ad d4 3b 8c 2a f0 73 5c c4 4d bb 98 ef d6 57 16 c5 39 6a 72 22 f9 39 a3 a 3d df 6 9b 1e a6 28
 38 fd 3c 92 e1 98 2c 2d c9 dc 2c 8b 7b 43 43 c2 94 b1 81 46 3c 2a d3 73 64 e8 e4 90 68 4 2d 5
0 ad 9 a7 4d e ae 25 a9 49 7f f 73 37 5d 5b af ea 3 9b 83 4a a7 6d f d9 e5 2f 0 13 91 54 c4 4a
 3a 64 62 a9 11 cc ee 7e 32 12 e4 c9 75 7f 14 95 db d6 d4 24 ba 2f 42 7c c ab bd 9e 4a bf 16 c
2 41 2c e8 e4 3d d3 b7 73 1c 25 2b b8 1c 6d 4a 17 18 3e ca 54 27 64 62 6b 74 25 11 b6 83 23 6a
 64 c4 47 e4 86 46 e3 9 ab 64 bb c5 26 d1 1 ff 65 48 b0 c6 55 d 2a bb 59 d4 e2 dc a df b e 77
d1 10 3e 6b a 7a c4 bc a6 9c 7 a3 4 f6 1d 10 c9 4b a1 ed 5f 9c 52 cc 5f f5 0 cb b b8 a e9 52 d
6 9f 1c 8e 3e d6 f 31 a1 75 33 72 c0 5 86 cf 8e 56 90 58 56 14 95 c6 b8 cb d4 e2 7e ee 91 b7 1
0 8b 7c 92 d8 81 ab 5f 6f 2f f6 b8 37 b7 dd 98 a6 b8 6d 9f ff 0 7e 3 ec 6e c0 20 94 cd 10 42 b
7 14 64 fa f1 23 a3 b7 d3 31 9f 16 1a d2 6a 11 df 86 d1 9d 3 94 ba fc da 2a ac a0 d7 80 6b 45
32 38 ed df 6f 28 f6 2a c7 68 59 69 30 9f 9f b0 d0 1b cc 59 ae ec 80 e9 9a 6e d6 e2 97 c6 33 c
2 fc c2 57 e1 82 e0 6f 33 89 c4 d3 26 c4 2e a6 82 34 ef e3 fb 8f 9f cc be 21 7a ca 9e 56 fc 45
 bd 66 fe b6 dc 79 41 e6 51 12 91 85 7c 5 2a 7d b5 50 7a e3 b6 d3 4f 3 2b 9a 2 c7 fc bc 78 b4
c3 fe c6 49 fe a9 eb e0 42 7a 0 41 64 24 df d2 ed e 29 95 67 4c c9 54 65 57 2 68 bd 88 c7 a 7c
 a1 7f 84 b8 df 50 76 f9 e5 26 96 fc 2b 51 53 e7 f7 b0 df 64 bf 2 56 8d 9f b4 79 e6 20 b8 99 a
 95 c b1 2b 48 aa e4 2c c3 e3 1f 1a fa d0 cf 5d 17 a5 58 32 fa 6a 2f be f1 c4 3f 48 a5 f6 ee 9
f 15 55 fe 6c 76 8e e3 dd cd 1d 99 9a d2 68 90 da 3b 8e ef 36 ef eb 43 b0 ec b7 e1 a1 f1 3f a5
 7e 80 85 d 6c e4 5e 38 aa d6 bc 41 51 94 38 8f 7a a7 e2 93 72 15 24 60 2c 31 ba 42 7b 6a c3 8
d 10 3b 7a 8f 4e 79 4 27 6b 40 63 1c 7c 84 27 4d dd de 9 2b 66 60 de fc 72 bf a9 3e 90 45 52 9
a 98 9f 5c 3d ab f4 39 72 78 cc 8c a2 73 37 cf b2 cd a9 85 a5 98 5f 32 70 6f e5 bc a1 81 fb 31
 9d f f4 b8 3c 6a 53 64 f0 36 44 71 e5 fc cc 3b ad b8 61 2c 0 c9 d4 4f 25 dd 12 21 24 33 35 7a
 31 4a 7f 3d 8c e9 e 39 18 90 e bc ee 49 37 f1 2d 11 a7 da 93 ab 27 bf e 2f 50 a5 bf 6f 57 77
6d 6c 24 e6 e4 d1 0 1f a9 34 dc ff d5 51 e5 d3 a0 46 f7 2c d2 46 92 1e 28 a 87 a3 d8 1d d4 1f
42 2d d6 99 29 6f e9 95 a7 8 50 28 d1 aa 51 f9 88 94 f5 64 94 69 d2 a7 c8 d6 9a 53 b3 5f 43 b7
 df 9c 41 b8 55 41 5e a3 50 6e 75 69 e4 8f 89 a6 b3 ab 4d 18 44 c 7c 23 26 d3 80 c 5f d2 d3 c3
 15 3a b8 d4 92 e9 71 27 a 8e 3b 6e 1 ff 85 6a 83 93 ab 34 b1 10 20 cd 63 6b 1f 6d 64 6f 99 cc
 d0 2a 80 69 fe da fa b5 7d ad 46 7a a0 c5 ca 46 74 26 e8 8d 49 be 62 ce 3 6f d0 4f 79 56 2b 9
d 63 be c8 83 cc 6f a9 6a 64 51 34 91 3c d1 78 71 48 51 6a 21 5 6a 3f 72 25 17 6e c0 9b 26 18
90 8a c7 1 51 cc 9c 77 69 f6 2b 50 29 2e cf a4 97 cc c2 36 a9 7c ed b4 de ab 84 f2 df ce a5 7a
 84 cc 75 c5 26 19 dc 37 cc 14 4b fd 4d c2 ef a4 30 d1 1d e9 f5 a9 10 48 70 7b 80 16 74 24 a5
95 9b dd 8e 43 64 5 30 dd 3a 44 b5 bf 56 f8 95 e0 4d c9 8c 6a bf 9d 47 c0 e9 b2 c b2 5e 44 6d
8a 5c cc 28 5b a6 a0 8a 90 65 89 7a 2 20 b7 e0 e 2d 97 b3 da cb 5d 40 89 d8 ad be 8d 8e e2 49
17 d2 61 a6 d3 95 4b 84 1d 3a 50 e1 4 60 2b 9e 53 b0 c9 2e 5e 68 8f 27 97 27 b6 65 8d 8d 7d ce
 29 61 aa 4f b1 aa c9 47 3c b2 1f 7f cb 6e 1a 71 9f 97 6c cc cf 80 f3 65 10 c1 5e 67 5 53 d6 3
8 f3 a2 d2 2d 5c 49 24 2c 9e be 5 a4 15 7d 28 53 7f 1f 55 73 5b 71 85 9d 76 56 1d 1a 6f 76 af
1e 1f ab c8 98 46 cc 3c 50 df 7d 5f 7d 6e 2e d0 ef 12 e9 c0 2 e a7 94 86 ae ad 4d b7 cd 1b 3 2
8 ac 86 ce f9 8a 1f c9 59 99 8 d1 cc 9e 69 bd 3 36 28 a2 4d 9f c8 d 19 10 52 d0 37 68 8d 68 46
 5a de 81 83 83 f1 23 49 d7 66 62 f2 f8 be 42 82 65 28 e5 f8 8a 37 e5 75 55 4c fc 38 a9 94 2d
7e c9 66 41 3 e0 4d 94 d0 ff 11 d0 18 13 e5 e5 28 5d cf ac cc 61 29 7 3f 27 f3 1f 2a 5a b6 a7
60 c0 99 f6 48 cd 77 f1 86 a4 1 5d b3 0 cc 5 33 3 26 ff e4 4f ea 1d 54 fc 15 30 7b 72 bb e9 e5
 5b b4 1e ae 29 55 30 70 c 70 9d d 4f d3 4b 8 5c 6f 9a 9a ce d2 43 91 3f b0 fd 11 8 73 3c 6c d
9 b2 2b 4f f 2 4f f1 7d 49 f4 3 f3 af 79 ac 2e ab 8c a7 8a dc e6 f2 a9 f3 f4 17 41 85 6e c8 bd
 15 8b 86 c9 55 ca b8 d3 76 5f 38 f0 2c fc ae ca e b0 3b bf d3 fa b7 8c 14 e1 1 17 8e df 7d c5
 56 fe 15 4 1d 5c f5 7b fa 32 79 e ba 7a c5 59 5e b5 2b ff 68 e5 fa bf 57 54 9a 78 11 f2 e4 4e
 b4 c7 fd 29 e2 5c f8 43 a8 2a a1 ca fb f1 a0 6b b0 ec 2c e3 e0 c2 e4 a6 e3 c9 a1 ed 19 86 f 2
f c7 56 a6 20 5e 25 e0 b5 14 dd c6 21 a1 aa ef db d7 34 da b8 5a c fd 92 ac 80 52 42 65 e5 23
74 f4 1c 28 52 e1 5a 28 ed b4 74 f9 8b 53 41 4e 98 37 4e d8 d 5a 9d a5 7b a7 6b c5 6 bd a6 ea

```
f 3b b2 7d 60 a4 16 f3 12 72 67 51 cb 8d e 54 61 23 19 2c 3a 8d 44 7 40 a1 a8 3e b3 42 cf 60 3
8 96 d 76 ac fd 29 c5 41 96 f1 b7 24 68 d7 a6 c0 f6 79 ac 50 77 38 f5 f2 7e 9f 2 55 dc b7 e5 3
c 3e f3 d0 5f 5b d6 1b 64 d4 b1 f9 d7 1f ce 5a 37 1c b2 4 95 5f ba ff c1 7 38 83 3f 41 d1 c7 d
8 f6 a7 b2 6d 40 bf f3 4c e5 d eb 57 9d 91 14 ca 22 5e 5b 88 d6 26 a5 fe 29 ec 6e 2f 80 a9 60
9e 84 83 67 f5 7c 48 5e 5a 3 b6 bd 98 67 ee 17 e2 f5 27 66 f7 1b 7a 2 88 50 97 94 3e 59 d3 ba
ee d0 5c d4 ec 9 e0 db 37 e2 94 1f f9 50 ce f0 f8 e0 2 8e 2a 73 ef 38 be 67 1a 19 1c 1 f4 c0 f
f 9d 7b c1 e0 2d c8 ce dc d2 46 48 54 7e 79 64 97 32 76 2f 2 5a 6 d9 1e 7e fe 80 5c 8e 3 69 dc
 8c 6d ca b5 24 c 1e b9 f8 4b 7d e5 a7 f6 74 b3 59 62 dd 82 bd aa b7 b6 9a a5 5d 72 74 fd 49 3
f bb 1a 92 6e c9 82 57 eb 52 ea 1c 7f 17 f8 fa 5b e0 ad 56 8c 79 5 89 81 f7 e9 8 8 e4 21 66 a1
 62 f9 46 0 7e 13 1d ee 5e 89 70 e1 7c 44 4c 41 bc 64 d2 3a 2c be 8e 8 56 af 94 8b c2 eb f5 74
 de 34 a0 40 8f 4f fb a1 d8 d ac 27 26 16 ff 0 81 23 76 54 40 5e f7 9b 55 58 92 38 cf 2 1a be
21 22 12 ee b2 75 af 76 fc a9 77 64 4d 53 35 f 48 8b 1a 55 6e 2a c8 aa 44 f7 15 1a e4 9 e0 c6
Time taken by serial highly coarse grained: 0.002232s
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fin
alImplementation/serial_code$
```

6.1.4. Fine grained approach

Parallel:

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fina...

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...   ×   neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...   ×

```
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fin
alImplementation/parallel_code$ g++ -fopenmp 02_fine_grained_parallel.cpp
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fin
alImplementation/parallel_code$ ./a.out
Enter the message to encrypt: Sample text for Roma : the novel of ancient Rome / Steven Saylor
.Bibliographic record and links to related information available from the Library of Congress
catalogCopyrighted sample text provided by the publisher and used with permission. May be inco
mplete or contain other coding.CounterChapter OneA Stop on the Salt Route1000 B.C.As they roun
ded a bend in the path that ran beside the river, Lara recognized the silhouette of a fig tree
 atop a nearby hill. The weather was hot and the days were long. The fig tree was in full leaf
, but not yet bearing fruit.Soon Lara spotted other landmarks—an outcropping of limestone besi
de the path that had a silhouette like a man's face, a marshy spot beside the river where the
waterfowl were easily startled, a tall tree that looked like a man with his arms upraised. The
y were drawing near to the place where there was an island in the river. The island was a good
 spot to make camp. They would sleep on the island tonight.Lara had been back and forth along
the river path many times in her short life. Her people had not created the path—it had always
 been there, like the river—but their deerskin-shod feet and the wooden wheels of their handca
rts kept the path well worn. Lara's people were salt traders, and their livelihood took them o
n a continual journey.At the mouth of the river, the little group of half a dozen intermingled
 families gathered salt from the great salt beds beside the sea. They groomed and sifted the s
alt and loaded it into handcarts. When the carts were full, most of the group would stay behin
d, taking shelter amid rocks and simple lean-tos, while a band of fifteen or so of the heartie
r members set out on the path that ran alongside the river.With their precious cargo of salt,
the travelers crossed the coastal lowlands and traveled toward the mountains. But Lara's peopl
e never reached the mountaintops; they traveled only as far as the foothills.
Sample text for Roma : the novel of ancient Rome / Steven Saylor.Bibliographic record and link
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.CounterChapter OneA Stop on the Salt Route1000 B.C.As they rounded a bend in the path that ra
n beside the river, Lara recognized the silhouette of a fig tree atop a nearby hill. The weath
er was hot and the days were long. The fig tree was in full leaf, but not yet bearing fruit.So
on Lara spotted other landmarks—an outcropping of limestone beside the path that had a silhoue
tte like a man's face, a marshy spot beside the river where the waterfowl were easily startled
, a tall tree that looked like a man with his arms upraised. They were drawing near to the pla
ce where there was an island in the river. The island was a good spot to make camp. They would
 sleep on the island tonight.Lara had been back and forth along the river path many times in h
er short life. Her people had not created the path—it had always been there, like the river—bu
t their deerskin-shod feet and the wooden wheels of their handcarts kept the path well worn. L
ara's people were salt traders, and their livelihood took them on a continual journey.At the m
outh of the river, the little group of half a dozen intermingled families gathered salt from t
he great salt beds beside the sea. They groomed and sifted the salt and loaded it into handcar
ts. When the carts were full, most of the group would stay behind, taking shelter amid rocks a
nd simple lean-tos, while a band of fifteen or so of the heartier members set out on the path
that ran alongside the river.With their precious cargo of salt, the travelers crossed the coas
tal lowlands and traveled toward the mountains. But Lara's people never reached the mountainto
ps; they traveled only as far as the foothills.
padded msg length : 1952
Time taken to AddRoundKey : 0.0036712
```

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fina...

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...   neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...

```
Time taken to SubBytes :0.003055
Time taken to ShiftRows:0.00299007
Time taken to MixColumns:0.0026768
Encrypted message in hex:
7f 2c 82 6f 9 c0 ae b0 f8 4a 98 c8 28 f3 50 12 7a a0 73 d 58 dc ba de 7c 88 7 67 d5 d 19 62 71
 59 c 5d 4f 7a c8 0 f6 ad 46 f4 d7 d8 f1 54 c2 a7 41 55 d3 3c 4b 37 1f 4a 49 d9 df cb e5 74 ab
 fb b0 38 38 2d 24 60 70 63 44 ca 7a 99 a1 1c d8 cb 12 21 21 e4 91 f6 a 7 fe 88 68 28 3c 37 ec
 3d 5 99 d6 b3 a2 ac 70 ba b7 53 4f 9a 9 e9 ab a5 71 30 1 1b ab 60 ca dc 51 ea fc f9 9d 7 a4 1
5 e5 44 5e a5 66 10 c7 44 23 ca 75 26 9d b1 70 f7 df 42 ed 5d 2a cf aa 95 51 7b 7a 1e b2 c7 33
 d0 40 cf c9 94 47 52 ae d3 62 3f d4 ca 9 3c 23 d2 36 16 23 5b 18 4d b4 c4 75 c4 5a 66 dc 64 b
d 7f b8 a9 fb d5 1f df 6e ca 5c e2 63 20 f7 71 f6 a5 2d dc bd f4 34 52 18 f5 49 29 c2 9d 6e 9e
 96 ad 6d 31 6b f9 dc 1f 69 26 1e b3 cf 62 d8 ac e8 42 69 8 67 1b ac 5 b4 8d 17 22 18 16 b3 8c
 e3 8e 97 10 e3 5e c1 3f d8 94 51 df 71 49 7 6c 9 63 a5 a1 89 61 be a5 f6 95 2 b3 9e e0 96 93
bc d3 ec b8 5f ab 23 92 3c 7e d6 60 5e 7b 5e cf f8 38 c2 cf e5 c8 cf 7f d7 56 9e 4a 7e b5 93 c
7 32 eb ba 48 59 a2 5b f2 d9 df c7 d2 c8 a3 41 da 67 c1 19 fb 75 4e 35 f4 3a 96 30 55 2c 2 5d
a3 7d 86 29 63 7 8c af 3f be 64 a0 d3 58 ec 3b 82 73 b1 5b ab 76 41 38 9d 4 32 dc ab ac a2 71
f8 99 db 2e 29 d a8 7d 38 f3 58 c fc c5 ae 1e bc bd 52 e7 71 8c bb 26 fc c3 8e 20 12 fc 19 66
0 a8 ce 31 6c f8 b7 e7 5d c3 97 93 1 c0 2c a1 6f c4 d0 6f bd 6f f3 1c 41 4 53 90 7d 9 dd b4 68
 34 43 a 83 68 45 b 5f ec 70 66 af a6 c0 dc 75 76 dd bb d7 82 84 c1 de 63 c7 61 11 a9 0 6 91 c
a 91 36 82 28 f3 5c b8 46 32 6f 5c e9 3d 22 ac 5d 3a 7f 53 ff 4c d7 3c f1 e4 6d 40 5c 48 8a af
 d1 b2 a7 76 d2 93 c3 97 fd 34 9e 94 ea a3 e6 6d d1 fc 13 54 7f 99 25 4b 81 67 75 4b 38 bf 50
7a 0 dc 32 6f 51 cd 17 69 9 b5 92 47 6f 47 7d 7f b8 10 56 5 8e 57 81 cd ae 4 3c 1e a6 15 dc 7a
 62 f9 40 86 12 6f a4 43 ef b4 61 89 56 c9 3a fa f6 76 7b 9a 93 3c ed 52 1b 63 78 92 8e ab f1
7a e0 8e 64 45 9e 69 b9 e9 95 83 e7 9 7f c4 e7 ea 95 87 fa ee c9 c9 ec a6 fb 9 e9 ba 90 6d 30
9c 59 e2 3c 8c 48 7a 37 f7 b4 8c 18 72 99 1b 7 ce 69 4b b0 14 23 3e a2 6b e0 6c 16 0 ab 8c ff
f5 b0 c2 c9 35 e6 2d 7a 0 49 59 e0 8a b df 50 ed 5a d1 4b a3 70 14 a2 a1 df e 3d 6f 4e e2 48 a
3 63 10 7f cd f2 f ad 8e 61 ea 41 8 dc a 15 23 e0 c 4f 6d 11 1 96 4d 3d 97 eb 7a 62 53 cb f9 9
5 e1 9b e0 35 6c 9f 7f 66 49 94 6f 24 28 37 63 23 95 bc 2c f4 8 3b 3b 1d fc f5 23 af 3 3c ff 6
c 7c 1 e6 87 dc c5 23 da 9e 9c a 15 38 28 32 4d e0 84 b4 3d f5 9e 78 31 1e 48 6f c8 ec d5 4f a
b c1 f 73 35 58 db ab 6e 76 3f 7a a2 b6 75 45 d5 69 95 36 f0 7c 3b 3e 11 77 34 72 b8 66 72 66
f0 5f 35 5 a0 1f 8 a 22 a 92 8 7b 1a 26 90 cf 5e 8f f8 2f a5 41 39 4d 7d 13 ab 5c ad 92 11 30
9b e 9b d6 cf a0 79 96 9d c8 bb 9b b6 1d c1 95 9a 7c 63 94 db ea 7b 5 95 37 e4 b2 83 f8 61 7a
7e 16 75 76 c8 17 8c 14 af 74 85 3f d2 14 99 5c 95 9b 55 af 69 53 d4 10 eb f5 1c 64 5b 15 9c a
1 c8 3a 8 7b 47 7 e7 96 ae 0 e7 7b a7 3c 89 7f 72 9c 13 98 29 4b 90 c4 29 ca 93 a0 50 b6 84 65
 ec ba ea d9 c6 4 e7 d9 8c c2 40 69 2d 20 e8 d1 14 af 42 e2 4c c1 9b c5 54 6 7c 1e 5a c5 21 ce
 9f e6 46 2f e1 28 8d dc 7 34 d1 4c 5f 67 e3 87 d0 e9 a0 14 24 29 41 b6 ec de 5b da 95 e2 93 b
a 19 dd 4b 99 cf 17 b1 16 6b 33 32 12 3 1b 85 bf 5c 2a 25 f1 aa 7 77 53 5c 3a f1 2c 53 c2 44 d
7 bd b6 74 f4 97 1f 20 c6 c2 77 98 e2 e0 2f 88 54 50 59 95 b1 7a 2e d3 dd d0 9b 8a 87 d1 28 7b
 5a 53 ec 43 6a 73 71 4b 45 ad 71 ed 9 f8 49 66 29 ef 1a 84 e9 79 74 13 f5 2a 12 87 d2 6d 32 a
e b9 78 4d e7 af c7 40 59 b4 16 f8 5d a3 1a de b5 fb 5a 6a b b ee 6e a1 b4 ed 5d a0 3a 66 58 7
3 f6 da a6 ad 4b 83 64 d2 4c 18 53 6e 27 7c 4e 3 33 c7 2b 66 48 64 51 3a 91 49 84 88 9d 9b 1d
39 44 34 fb 3f da 5f fa 51 bb ac ac 68 c2 56 ec a5 2b 63 6a 9d 8a 51 14 58 3 a6 c da 46 4f f7
d8 b5 d0 87 a2 db e4 7d f f9 ec e8 9b 24 e9 af d2 7d 43 a6 a 94 db 48 19 eb 17 f3 e6 50 92 6d
86 a2 ad 2 26 1e c9 c9 4d 96 de f3 e6 cd 7a 27 76 2f 22 56 11 4b fb 8c 33 73 17 11 a3 85 3c fb
 87 f4 3b f4 1a 16 50 2a 88 6d 82 40 f 7c bd 31 a3 e7 57 2e 74 d7 54 7f eb a9 62 71 4a 72 58 f
f 3a f2 ef 6 4d fc 51 9 98 a2 5e 4f e3 13 7e 4c 53 c c4 fb d3 20 29 59 71 4d b6 f c6 b6 4e 0 c
f 4c b3 78 a8 eb e1 f6 a6 16 b8 e1 ae dd 52 b0 6f d7 34 fc 27 b5 b0 e5 68 d0 db 6c 4f dc ce 41
 60 68 af a9 53 1d 86 fe 5b 9a 49 75 e1 a 7b 5e 77 da 75 5a f1 96 3 5d 74 b6 4 45 73 c0 b3 f1
```

```
15 d9 df d2 cc eb be 16 9 55 28 47 1d 2d be 2e 15 1c 35 25 b4 2c ca 33 67 da 2f 14 d2 f5 90 69
 3c 18 b8 35 9b d 0 98 51 b4 63 44 8e a8 da 17 3e b8 65 db 21 d2 3f 74 46 d3 c 8c 6e d3 ef 37
86 34 1e fc 92 c1 b1 5e 65 1e 20 a1 7c 51 78 6 c6 20 a6 74 a fb 18 59 b0 7c d8 de 1f 14 f7 4d
a1 7f 79 d c1 72 9 1f e0 1a dd 2c b7 ba 41 ec 3a 9b f4 32 98 7a f0 6f 83 d3 f4 bc c4 22 3b a7
73 e8 ca 60 e6 fe 14 4b 9a 26 b2 4e 91 32 b9 6d e6 f8 95 a9 3e 57 15 66 64 bd a2 f4 b9 e7 6e d
d 25 7d fb e3 1e 54 c d6 cd e5 da 60 db b2 de 43 22 e7 ed 7a c4 6d 8d 5c 8b 1e 33 d3 12 34 18
17 b 5e 93 b3 4e ed 78 e7 d7 30 16 ef a6 c2 cc 6 a c4 4b b2 95 ed 85 5d 58 da 81 ae dd ce ac 9
9 c9 b3 fb 64 55 75 42 2e 6b c7 e0 0 c6 cd 17 65 a8 47 8 a9 3d 59 7f 2d 43 72 81 4e 55 ae 74 a
c e6 4e b4 5b 81 c7 45 1f 47 ff 1b 47 97 73 af e 34 dd c3 79 6f 33 2d 72 25 6e b4 fb 93 1c d5
72 a0 2e 77 59 e7 5a f 16 dc a5 26 d4 a9 9e a7 7b f1 2e 79 ca 2c 98 38 5a 97 cf 6d a2 61 2c 41
 c6 10 e6 7e 11 bb 69 4a cd e 40 84 84 fb ae a0 d a3 30 48 9e 67 b6 70 d 94 ad 1c d2 7f e 9 9c
 64 49 de fd f0 fb 4a b1 91 41 d2 7b 3 6a e4 bf c5 ea fe 23 f 6c 10 d3 3 e af 9d c3 f9 9c f5 2
0 b4 87 b4 4f d7 73 ea 48 74 15 c6 8d 8d 17 ea 75 b 15 1e 66 6d b5 1 dd db 31 47 4c a9 51 84 f
f 5 4d dd 42 62 49 74 f9 60 5a ca fd ea f7 d8 6f 17 a6 2d 1e 17 51 2f 6f 40 90 68 b1 8a 35 ce
13 77 a0 1c d3 6f 97 de 52 ac 61 ea 67 1c 92 93 8f 6c 9f d1 c2 1c cb a0 58 df 37 70 bf 45 7a e
1 e9 a0 16 23 d2 48 d0 60 df cb bc 27 46 c3 26 6f 5a 3a 5e e3 d7 ca 6a 59 57 1c d7 2d 8c e2 33
 4a ab 54 98 5e 76 25 9a 77 14 3c bd 62 ba b6 71 28 ad 25 e6 5c d4 44 96 2e d4 4 6 e2 89 50 a9
 6f 88
Time taken by parallel fine  grained: 0.043992s
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fin
alImplementation/parallel_code$
```

Serial:

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fina...

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...   neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...

```
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fin
alImplementation/serial_code$ g++ -fopenmp 02_fine_grained_serial.cpp
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fin
alImplementation/serial_code$ ./a.out
Enter the message to encrypt: Sample text for Roma : the novel of ancient Rome / Steven Saylor
.Bibliographic record and links to related information available from the Library of Congress
catalogCopyrighted sample text provided by the publisher and used with permission. May be inco
mplete or contain other coding.CounterChapter OneA Stop on the Salt Route1000 B.C.As they roun
ded a bend in the path that ran beside the river, Lara recognized the silhouette of a fig tree
 atop a nearby hill. The weather was hot and the days were long. The fig tree was in full leaf
, but not yet bearing fruit.Soon Lara spotted other landmarks—an outcropping of limestone besi
de the path that had a silhouette like a man's face, a marshy spot beside the river where the
waterfowl were easily startled, a tall tree that looked like a man with his arms upraised. The
y were drawing near to the place where there was an island in the river. The island was a good
 spot to make camp. They would sleep on the island tonight.Lara had been back and forth along
the river path many times in her short life. Her people had not created the path—it had always
 been there, like the river—but their deerskin-shod feet and the wooden wheels of their handca
rts kept the path well worn. Lara's people were salt traders, and their livelihood took them o
n a continual journey.At the mouth of the river, the little group of half a dozen intermingled
 families gathered salt from the great salt beds beside the sea. They groomed and sifted the s
alt and loaded it into handcarts. When the carts were full, most of the group would stay behin
d, taking shelter amid rocks and simple lean-tos, while a band of fifteen or so of the heartie
r members set out on the path that ran alongside the river.With their precious cargo of salt,
the travelers crossed the coastal lowlands and traveled toward the mountains. But Lara's peopl
e never reached the mountaintops; they traveled only as far as the foothills.
Sample text for Roma : the novel of ancient Rome / Steven Saylor.Bibliographic record and link
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.CounterChapter OneA Stop on the Salt Route1000 B.C.As they rounded a bend in the path that ra
n beside the river, Lara recognized the silhouette of a fig tree atop a nearby hill. The weath
er was hot and the days were long. The fig tree was in full leaf, but not yet bearing fruit.So
on Lara spotted other landmarks—an outcropping of limestone beside the path that had a silhoue
tte like a man's face, a marshy spot beside the river where the waterfowl were easily startled
, a tall tree that looked like a man with his arms upraised. They were drawing near to the pla
ce where there was an island in the river. The island was a good spot to make camp. They would
 sleep on the island tonight.Lara had been back and forth along the river path many times in h
er short life. Her people had not created the path—it had always been there, like the river—bu
t their deerskin-shod feet and the wooden wheels of their handcarts kept the path well worn. L
ara's people were salt traders, and their livelihood took them on a continual journey.At the m
outh of the river, the little group of half a dozen intermingled families gathered salt from t
he great salt beds beside the sea. They groomed and sifted the salt and loaded it into handcar
ts. When the carts were full, most of the group would stay behind, taking shelter amid rocks a
nd simple lean-tos, while a band of fifteen or so of the heartier members set out on the path
that ran alongside the river.With their precious cargo of salt, the travelers crossed the coas
tal lowlands and traveled toward the mountains. But Lara's people never reached the mountainto
ps; they traveled only as far as the foothills.
padded msg length : 1952
Time taken to AddRoundKey : 0.000295093
```

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fina...

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...   neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...

```
Time taken to SubBytes:0.000252303
Time taken to ShiftRows:0.000136416
Time taken to MixColumns:0.000228495
Encrypted message in hex:
24 38 27 91 e2 9d bf fa 15 cf 58 5c d7 b2 fa c 1e 4b 7b 31 6 9c 61 95 41 16 4d b7 c8 b5 41 a1
e0 6a cc 90 44 c8 40 2c 34 f0 7f 23 2 a4 86 ec 5c 68 e0 d2 93 7d bc f3 bd ce 10 52 c9 8c 69 c3
 e6 1b 71 a4 9b b5 aa a2 4a 20 e6 df bb c4 4e fb 91 34 78 fd 54 c8 98 fa 3d aa 85 1f fb a3 8b
d7 aa c4 c6 89 7b 9f c8 80 e 89 cb f0 35 ad c9 4 bd 8 15 af 7c 0 cc 6f 87 31 b4 12 1c ec cb 50
 28 a8 16 72 71 48 3c f3 e8 e4 3c 29 96 f3 7a 2a f 6e 16 7d 5e b3 4e d4 a0 14 83 f2 48 41 7a 1
e e c6 b6 91 64 c4 5f dd de eb b3 16 1 ed 50 b6 e3 e3 84 c5 37 c1 21 4b b7 5a 3d 52 de 27 b b3
 56 ef 88 e8 b7 72 1b 20 74 97 71 9d 23 57 b6 da a2 58 66 e1 91 52 ba 52 45 ac c2 a6 62 e9 cd
c 95 11 f2 8 45 61 dd e3 aa 19 a2 df d9 4c 3b 9b 6d 9c 96 44 ba c 24 af c6 63 76 65 a3 97 a ac
 27 39 66 7 c4 80 69 41 bf fb 7f 4e a3 a7 f7 91 92 b 9b 42 c1 2c 13 33 e2 c 22 80 3a 1c 2 fd c
b 7b 75 5b bf f1 3a c0 7e d c9 92 78 b5 4d 3b da 5d ed d2 53 62 56 7d dc 9 2b 1c f 20 d6 ac f
9 b6 62 ae 3a f5 14 0 ac c0 5d 73 82 97 4f 24 84 c0 d 78 1b f0 bd 15 a5 d6 14 81 c 1 88 a3 d f
9 8a 4c a6 59 4e 5 49 1d d3 cf 2a c4 cf 99 fc d0 73 2d 99 98 ef 92 99 a8 6c ee 66 72 f4 4c 55
92 fa dc 7 7d ce 88 96 7b de ec b7 91 3d 0 cd f2 f9 6c fb 94 19 d5 f1 f6 a4 39 7a 40 1b 60 1d
42 84 ad 4c ca bb 28 4b 34 ec 61 99 8c b7 8b 9a 20 a2 d 7 4d 37 57 2a 1e 99 a2 aa b9 5c b4 16
e e8 e8 2a 97 ad b8 6e 77 c6 42 b9 ef a5 d5 68 5d 8 57 5a 10 e2 ea 75 9f a9 e2 59 44 e7 35 ea
eb be 48 ac e9 dd b4 ca b9 85 72 e2 a7 66 ee e1 5e 1b 88 f3 30 e1 f d5 7 a3 b3 9c e6 9 6e 3e 1
3 2b a8 f4 c2 26 2f 21 a 40 e4 8d e 1e a1 13 81 db 72 8f cc 3f 5d 38 8c 90 84 b5 de b7 3f 70 a
e 6f e3 6f 39 a5 6b e5 8 47 b4 da 69 1b b6 9e dd e5 63 4b 49 b4 15 97 49 70 a0 4c 8f cc 94 e0
8d 96 77 22 93 fb 53 e9 2e d1 9b 20 33 73 90 d2 a8 2a cf fd ba a ca ec ee db 23 37 b9 38 63 a2
 c5 7e c1 69 82 77 1d ba b9 c4 44 d4 7f 68 cb 3c 59 6f 2b a6 2a 4e 77 ff 1b 50 5 88 99 b9 42 b
3 b0 8 97 74 20 f7 4 57 53 3 7b 3b 21 7a 4b c7 15 9e 3b 2d 6b 9e fe 5 c3 26 d9 22 5f cb ee eb
1f f1 1f 10 68 f8 aa 4f 62 95 32 4 13 76 81 ff 3c 27 80 d0 44 be 14 42 2d 62 a8 24 3a b0 a3 77
 ae 58 cb 18 a0 97 a8 86 1a 6a 1b 5d 7d 79 6c 78 d7 ef bd 7e af 0 2f 8b 6a 1c b0 a3 1f 9b b8 6
a 44 b e9 70 16 99 2a d0 67 1a 47 44 7 33 45 10 5d df cc c4 4f aa 47 bc bc 71 c6 c6 d5 96 e8 9
e 44 99 20 a7 9f 72 6c ca 8a 3 e4 57 8c fe b2 e4 33 84 67 43 e1 82 72 ce 2d 15 b4 3d fd 7 1f a
5 1e 32 6e 38 77 9c 10 9d 12 9e bf 54 fa 68 fd 34 d 9c ec 34 dc 6a 3b 80 a fc 99 16 fd 3f 5a a
2 21 fd db 35 3 70 34 9b c5 a7 7 65 e1 a0 b7 40 65 3c 57 49 a2 b0 ce 2a d4 38 a6 7f cc 51 cb 5
1 c 1 77 c0 67 e5 d3 2 64 a4 39 43 bd 7b 79 99 e7 bb 88 ee 70 77 b3 ba 3e 45 ce 43 f4 1f e4 3b
 1f 43 c2 7c 94 f1 5f 8d 7e cd ba 7d a8 6c 1f 15 b8 76 2e 4d 24 4b 1c 45 64 9d c8 f5 1a d7 d1
ac 83 86 31 8c 44 ea 2e b6 3b d6 67 40 3f 4b 91 2b b0 91 40 f1 1f d3 3d 83 a9 43 c d5 44 33 9b
 94 f9 8b 8b a0 c2 7f bd 2e c0 4f 9d 41 a4 be db e2 c3 52 d8 94 1f 23 f8 6a ad 72 24 14 af e1
46 21 38 3 c6 8c df ca a2 9d 85 8a 38 f2 3f b8 18 77 5e 12 3d 7b 26 ae fa cf 5e f8 66 ea 58 26
 85 f3 fd 93 6c b8 88 6d 6e 3e 6d 2b 3 23 76 26 55 45 a6 cf 48 9d e2 ef 69 ac c2 bf e3 38 59 7
6 1f 95 6a 38 ef 50 e2 c8 9e 25 78 5f f6 f7 c5 49 d6 76 bb c3 db 15 ad be 54 82 30 ea 15 60 73
 7a 29 cd 61 50 f6 fc 5f cb 6a 56 ff 49 15 30 3f 0 8 8e 45 f8 98 64 4 3 4c 6a 36 c4 b5 69 77 6
e cb c3 fc 91 94 37 28 22 4e 66 17 4a b0 41 6c c7 a 4f 52 13 13 99 b5 a7 df 56 d1 b2 dd ea 28
79 43 d5 a b0 36 e8 d5 b8 d1 ce 75 ed ff 6d 7e 56 8f ac 62 c9 5c 2b 8b cc b9 69 70 c5 7f f2 33
 25 d6 ec c9 4d 70 64 e9 e8 c3 a6 c1 fd eb 12 f8 9b 6d 52 67 e5 cf ac 86 c3 2 99 7d 37 14 a c1
 79 30 7b bb e7 6b d 6b ae c5 b3 8d 6f 3 51 94 fe b0 bf 8d f5 21 9d 5f d3 ed 1f 59 f4 1d db 2f
 44 63 66 11 63 9e dc ed 9b 9b ec d1 56 82 90 fb 9a d8 d7 d8 cc f7 25 38 d9 ea 4f 7 ea 76 70 1
8 9 a8 51 48 d4 1e 62 77 d d2 a2 e3 a d9 f 2d 17 64 3e 35 b8 77 90 bd b4 a4 cb e4 7d b4 be fe
3b 96 91 59 6a b2 5b 76 cd 57 40 9 9d a1 f4 4f 38 b7 ed c5 bd e b c7 ef b0 4b b4 f2 4c 64 29 a
d 41 a 47 5d ea eb 5b 1b c3 81 91 64 a3 d9 db e4 3 d4 4b 37 60 68 8e d2 f9 e ee 3d f5 ac 16 61
 83 cc 99 28 c3 c8 b5 a8 7c e0 27 37 1 ba 20 60 73 f0 cc 52 97 72 0 3b 55 65 bd 30 1 eb 5f ac
```

```
 83 cc 99 28 c3 c8 b5 a8 7c e0 27 37 1 ba 20 60 73 f0 cc 52 97 72 0 3b 55 65 bd 30 1 eb 5f ac
f f5 74 43 3e be 6a be 76 d2 af ee da b5 9b 79 3e 75 8f 16 d7 b9 1 42 d6 27 2c 3e e4 30 73 30
af da 7 8a 8f a2 f4 c0 8b e3 f4 37 8e bd d0 e5 59 32 55 7 77 47 66 42 4b 66 24 db f2 72 3a 96
66 99 9c 26 48 cb cd 96 cb ca a2 b5 ee f0 58 3a c5 22 79 b6 30 db d6 9d b9 64 aa 5a db 87 36 6
d b f 23 85 5 e0 91 ea 6b 8c 94 6b 70 7b 85 ad 8e fa 58 36 38 1b e1 59 a5 cc 5b e9 dc d7 1b e9
 23 3c ed f9 ab ed b9 85 be c0 f8 33 30 30 5b d4 ce 7a 50 c4 cd e0 e0 51 65 c8 4b c5 30 93 83
79 4b 1d 88 27 11 2b 56 9c 3a 27 84 13 20 46 a0 90 a3 5d 7d 54 37 18 47 a2 2a fa 5a 90 c1 fc 7
a cb 2f b9 6e 6 25 ae 29 3 7e 62 d2 a6 f5 26 2c 47 7b 30 e7 15 b4 d5 f6 5b 71 c5 4f 53 c4 4 da
 4b 42 16 0 aa 36 c6 27 f5 21 20 dd 6c 40 49 72 6f 91 e5 1c 7d 33 e8 39 2b f2 49 33 b1 1d c8 7
b 91 c e0 7c 2b 90 72 51 a2 1 77 1a 8 3c d1 d9 8a c2 6a e9 21 41 f bf 1f d1 23 df 9d e 1b 22 5
0 11 29 3e 60 b dd 1a 4f 2 c2 fe 2 5f 89 c8 32 75 73 7f 5f 5e 9c c0 2e 9a d8 b 1c 22 57 13 8e
fe 68 ee ce 26 8a b5 b7 d5 7f a0 4c 27 d8 58 5e 3 80 73 6d 7c 81 5b b9 4a d6 6c f2 e1 99 40 f0
 75 77 b e4 ee bc 5d 9e de db 2f 90 6f c 6e 0 7d a2 5f 75 64 7f 63 f0 5a b1 88 a8 7f e5 ca fc
93 63 f5 a9 56 af 73 7b 4b f bf 3a 44 22 4a 6c ed 96 b8 d2 43 ae be 2c 2b 63 fb 30 35 92 db 18
 c3 4c 6d 4d 5c b4 7c 7e 40 9a 74 c5 ad a0 8e 3b ea 8b bf c0 fd e1 75 77 da 71 2d 63 ee ef 7b
46 38 88 4c e6 f0 43 f3 12 25 5c c5 79 db 3c 92 a2 68 6c 6f 8c 3d 63 ac e1 b7 80 d2 24 ab 34 7
6 d6 5e f3 af c9 f4 8f 50 a6 18 9 9c 93 1f 50 a2 36 42 87 3f db 0 a4 2e 64 14 d3 27 89 92 9d e
3 86 2e bf af c4 33 13 fa 3b d fb 30 79 29 21 e1 df 7e c1 5f 28 f2 e9 17 ec c0 d4 de a3 6a dc
95 4a 35
```
Time taken by serial fine grained: 0.003132s
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fin alImplementation/serial_code$

6.1.5. Better Fine Grained Approach

Parallel :

```
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fin
alImplementation/parallel_code$ g++ -fopenmp 03_better_fine_grained_parallel.cpp
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fin
alImplementation/parallel_code$ ./a.out
Enter the message to encrypt: Sample text for Roma : the novel of ancient Rome / Steven Saylor
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catalogCopyrighted sample text provided by the publisher and used with permission. May be inco
mplete or contain other coding.CounterChapter OneA Stop on the Salt Route1000 B.C.As they roun
ded a bend in the path that ran beside the river, Lara recognized the silhouette of a fig tree
 atop a nearby hill. The weather was hot and the days were long. The fig tree was in full leaf
, but not yet bearing fruit.Soon Lara spotted other landmarks—an outcropping of limestone besi
de the path that had a silhouette like a man's face, a marshy spot beside the river where the
waterfowl were easily startled, a tall tree that looked like a man with his arms upraised. The
y were drawing near to the place where there was an island in the river. The island was a good
 spot to make camp. They would sleep on the island tonight.Lara had been back and forth along
the river path many times in her short life. Her people had not created the path—it had always
 been there, like the river—but their deerskin-shod feet and the wooden wheels of their handca
rts kept the path well worn. Lara's people were salt traders, and their livelihood took them o
n a continual journey.At the mouth of the river, the little group of half a dozen intermingled
 families gathered salt from the great salt beds beside the sea. They groomed and sifted the s
alt and loaded it into handcarts. When the carts were full, most of the group would stay behin
d, taking shelter amid rocks and simple lean-tos, while a band of fifteen or so of the heartie
r members set out on the path that ran alongside the river.With their precious cargo of salt,
the travelers crossed the coastal lowlands and traveled toward the mountains. But Lara's peopl
e never reached the mountaintops; they traveled only as far as the foothills.
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n beside the river, Lara recognized the silhouette of a fig tree atop a nearby hill. The weath
er was hot and the days were long. The fig tree was in full leaf, but not yet bearing fruit.So
on Lara spotted other landmarks—an outcropping of limestone beside the path that had a silhoue
tte like a man's face, a marshy spot beside the river where the waterfowl were easily startled
, a tall tree that looked like a man with his arms upraised. They were drawing near to the pla
ce where there was an island in the river. The island was a good spot to make camp. They would
 sleep on the island tonight.Lara had been back and forth along the river path many times in h
er short life. Her people had not created the path—it had always been there, like the river—bu
t their deerskin-shod feet and the wooden wheels of their handcarts kept the path well worn. L
ara's people were salt traders, and their livelihood took them on a continual journey.At the m
outh of the river, the little group of half a dozen intermingled families gathered salt from t
he great salt beds beside the sea. They groomed and sifted the salt and loaded it into handcar
ts. When the carts were full, most of the group would stay behind, taking shelter amid rocks a
nd simple lean-tos, while a band of fifteen or so of the heartier members set out on the path
that ran alongside the river.With their precious cargo of salt, the travelers crossed the coas
tal lowlands and traveled toward the mountains. But Lara's people never reached the mountainto
ps; they traveled only as far as the foothills.
padded msg length : 1952
Time taken to AddRoundKey : 0.003243
```

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fina...

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...   neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...

```
Time taken to SubBytes :0.00295245
Time taken to ShiftRows:0.00273239
Time taken to MixColumns:0.00263522
Encrypted message in hex:
f0 b3 ec 50 b9 12 5d ee b7 55 d8 65 41 72 ba 5a 28 d1 b7 5e b4 3e 25 4d 4e d8 3f 6c b9 53 fb 9
c 8d cb dc b2 bf 65 84 fe 68 13 1f ee 5b 28 b6 f5 1a 3c 3d 44 78 d0 4c 9d 4a 97 df 30 65 e be
c7 2a a4 24 fc 7f 77 3c 28 c a4 f6 51 ad 6b ee 5b d7 f5 f3 fe 12 49 44 dd 8a 94 c0 5 61 f9 4 2
2 80 44 5b f 14 f4 e6 d6 49 76 1 40 ec 4f be e6 9a 36 fa b0 26 61 df 7e 95 25 48 41 a4 5a 74 5
4 c4 6f 22 b4 37 73 32 82 f9 ce f5 c5 ad fc 98 c7 56 91 ad 20 3b 94 49 6a 20 b0 20 0 3f 6f 4b
5c ee 6d 66 40 44 7d e3 37 17 5e 9a 12 22 c c1 40 3b 6c fd 68 59 21 c0 19 4b e4 20 98 4c b6 ca
 10 84 96 8c 12 f2 7d 37 bd 4e b9 34 24 7d e b5 32 da 66 5d c5 b6 4b c d1 f1 b 33 39 13 36 b9
a 65 cf 95 fe cb 2e fe bb 5f 41 6 39 4e 2 17 3b d 56 11 1d 9d e4 87 60 1 e8 61 8f f7 1b 4d f4
7b 37 cb f8 2d 3 a1 c1 5 fa ee d3 37 ed 35 92 da 49 34 21 15 c0 43 33 83 96 d3 b5 d5 ea 95 fe
5e ab fe ea 4c be 91 b5 1e 46 9d dd e8 2b 3 8f 1e 97 cc f9 19 4a bd 8f 25 e3 b3 1 d 5e 5d 6b b
2 61 2d 72 24 c5 65 cb eb 63 ae fd 7f 88 59 54 fa 6f 61 48 25 e0 46 d0 ad 9c 41 3b 41 99 f8 e8
 9a 6c 65 b7 38 3d 5d b c6 b9 f 80 61 fe 9a 8 a5 77 8c 97 a7 5c a0 d7 b3 16 d 6 54 24 2f 72 96
 e fa a e1 13 76 92 8a f4 22 e7 9f d9 a8 1e d7 fa 6a a6 b5 56 82 7b 9e 9b b0 bd 25 91 ac c2 46
 5c 3a 12 c7 c9 2b 2b 55 92 f c2 ba 35 e3 5a 75 1a 2 5a 3b db 91 da 13 fb d9 f5 5d e1 cb ca 44
 8 cc 67 f3 a1 8b 4f df 45 71 8e 7d 81 ac 41 b2 b7 7f c 3a 84 2b 10 ab c0 10 58 f2 b9 f0 1b de
 2c d7 13 61 58 59 87 32 15 71 e4 d9 3a 14 7e c4 a7 79 95 6c a5 1f f4 aa 24 f2 b2 f d3 26 30 1
c ec 4e 5c 49 24 58 20 6c 57 ee fa db 56 f3 a2 82 4 e1 82 9c 36 b9 f1 25 ae 67 9a 46 bf 3 c4 7
7 99 fd 4a 7a fb 68 e0 1a 42 95 fe 99 29 4 87 32 7a fd 1e 3f 8c 94 13 36 a0 44 aa ce a6 b2 8d
5f dc 4a f3 dc b2 bb 54 f3 7 12 47 7a fb bc 16 ed 2 bb ba db fd bb 20 d1 f4 6c 2a a6 df df e0
94 d9 37 91 f4 6e 24 ab 84 8 63 d8 d2 e4 a4 b6 0 37 f1 ed 72 74 ff b5 89 78 60 93 ef f3 17 fa
b8 ac b6 df 8e ab f3 a0 83 6f 2d 8f d3 be e0 b2 0 a3 f6 13 fa 4c d8 3e 1e ea 89 b cf 3d be 7c
12 8 c6 4a b9 6f 5f fe 44 a7 7f 8c d1 ff dd 49 c0 fb 68 fb a3 54 5e 26 b4 d0 1f 47 bc 5 cc 53
2 ac 48 cb 40 f8 34 ab 3c 4f e1 6a 89 2c 27 a1 4 7f a5 25 59 34 81 f7 ca 25 dc e5 67 f3 16 9d
58 4e a3 ff c 3d 33 18 9 54 55 90 a9 40 9d ce c7 6c 83 ee a9 38 69 7a ac 44 90 1c f9 12 ba 19
f2 b4 c3 85 e6 2a 72 e3 28 25 ee 2c 7 a9 bc 46 7f 80 cc f3 5e 6d 2d 3a 8c c1 3f 50 ed f7 ef a4
 14 b0 1e 54 65 a bd 37 1d 13 7b 8b 8f 66 a2 bb 89 5c b9 e4 3b e7 52 ae 15 49 96 e2 82 1c f0 d
a a0 6f 97 92 ad 23 b9 34 a4 25 d a3 ba 2b 66 97 4b 89 73 57 33 f b6 32 97 b2 79 3c 4b 49 e3 b
f 21 23 b1 af e9 ce fa 94 e e1 e9 4f fa d 1c 9e d3 50 e2 a8 d1 d3 f2 84 82 91 48 17 4c 4c e fd
 db db f4 72 99 1d a7 c6 fc a6 fd c9 e4 bc 97 54 3d db 26 4e 73 5d d4 db f4 98 37 9e ed fa 88
5f 22 ac 85 4b b0 33 aa cf 75 c7 14 70 b5 7e 4c 7f 12 e1 83 86 f7 5 52 ba c ae f9 34 10 eb d3
a1 c 23 f8 f8 e8 45 bc c1 2a d8 db 85 61 5f ea 96 82 39 6b 47 a5 9e f9 af 70 81 1b 3d 12 45 1b
 83 49 fa 21 28 25 3b a4 38 89 b6 d1 86 60 8a 9 49 84 92 e 3b 8a 5f a0 3a 4e ed 5d b7 44 5 97
18 55 b5 4b bb 89 f7 9f 2e 26 96 63 ab a7 d0 8c 9f f0 38 45 57 4 29 d4 a5 39 a 84 54 cf 9e 54
b5 d0 9c 11 4e c e 1b 4e f5 f5 39 8d 4 c4 67 23 47 6a 4c 6e f9 df 7d ad 61 18 1f 77 4 52 86 51
 d5 ce 7e cd 8c 19 a6 30 32 e dc 80 77 11 5 c3 c1 e8 3e fd 51 9 13 51 5a 49 f6 cc 7d a0 28 9c
38 b4 8f 53 eb 8 ad c5 87 97 dd 23 34 5f e 24 71 45 f 38 1d 88 6f 28 3e 5d 46 5a f0 e4 f b8 1d
 a4 68 e b9 e4 d1 a2 80 f9 44 56 ef 4a b8 78 32 6b 5b f4 c8 a0 45 2b 67 6d 3 2c 2b be a8 9 a4
52 45 69 be 6d 92 cd 33 b7 1a 5a d8 c2 35 e3 d6 2c 44 2e f1 70 df a 87 f4 66 fd 26 6a 3 b3 32
c8 b6 fd 4f 3d 95 b0 ca b5 f1 54 73 6a 5c 3 a8 c 82 f9 f0 15 98 3a 1e 25 5 f2 25 e1 21 78 de 5
2 62 ab 6e 6b a5 7a 6 1e f a9 94 8 b1 33 1f 82 56 dd 37 7d b 8a 37 fe 92 b4 a3 cc 59 75 6f f a
2 e0 3e 25 a7 11 d6 8 bf 31 31 2c 95 38 89 d e6 df 94 88 cc 86 be 71 7f 2b e7 60 81 27 63 55 2
5 53 5b d7 9f 2d 11 32 ab ce 22 cd a9 7b 8f c4 a6 4f d1 8 9d f0 8f ae 7 24 5e 2d ec 5c 5c de a
c f2 12 15 23 c8 62 47 1b 91 10 2c 44 4f ff e 8c a d3 7f 3f 52 cb 7f 57 a6 96 e8 1a bd 10 ea c
6 54 d1 5e 55 12 77 86 da ef 73 c2 e7 68 92 ef e 6d 37 89 7b 90 dc a e1 bf c bd 75 f6 2a 9a 85
```

```
 aa 6f 80 5a 6a cd d8 be 6e 2e e5 24 2b 10 d6 a3 a0 0 cd 54 6c 5c 13 d5 91 6 bd 31 e2 ac 98 b2
 b5 18 bb 5a eb 14 4d 2f 9d 77 9e 4d 89 bc c0 6e 3d f1 a8 fe 40 61 78 60 2c c9 3 e4 6b 2f 50 9
 e 51 e1 be fb 6b b2 1d 29 a0 a7 a9 82 ae d0 e8 a4 97 9b 22 84 46 bb 9f ae 6d d2 b8 99 4d 2e 10
 61 ef 1f 3f a0 3d 2d 81 be ed 9d f3 ad ac 57 ea 15 fe 6b 7f bf ae 2d c8 3d bd ee c0 db 16 3 9
 1 bb ed 70 30 55 65 eb 8 d0 1f ef bb 49 54 55 a9 87 6a 4e b3 56 f9 59 f3 19 5a d2 b2 4b d8 ba
 92 8e 4 bf 2d 68 f3 42 f2 24 ce fc 86 fb 6c 46 6d 52 3f c9 2 59 2a 81 50 51 13 7d 2d 90 e8 b8
 a5 3c dc 2b 9f 52 c1 7d a2 7e 14 c2 89 51 55 f2 3 83 b6 f7 1d ea bb f1 34 12 97 46 23 4d 37 12
 9f 9b f8 b2 ba cc bd e0 c c5 b3 30 ab 17 cf 8a 48 45 2a b0 8f d1 b8 7d e5 6f fd 58 b4 cd ea d
 f dc af f7 dc 6e b6 81 bd 47 3d 33 0 58 7a 57 6e 9c 99 7 c5 8d d5 94 76 c1 29 81 e 47 a6 34 7c
 84 b3 f1 e9 62 bc 0 f4 c6 bd 1 e8 20 ec 81 e0 f 76 46 e1 58 ff 19 a4 49 b9 29 5b dc 45 35 3d
 58 65 7c 73 8e de ea 6c 6e 8 2d 39 9b c0 79 86 a9 2e 16 15 7e 2d f0 57 fc 7b 76 2a db 28 7b 2b
 67 35 26 e9 cb 79 c8 8d 54 d7 fd 61 25 e9 5a c7 de 23 d1 9 24 c4 5a d4 d7 3 7f a9 c2 a0 a2 85
 ba 5 a6 25 86 3a 88 8d c5 ad b7 77 a 45 7 c1 65 b7 c7 23 fe 45 99 91 11 41 c5 2b f2 f0 6d c3
 67 3f 87 4e 1e 94 7d f1 f 1d 53 2b f4 6d 50 0 f1 f9 67 91 e6 80 58 20 f5 36 23 c8 d5 89 ea 51
 4c c3 ad 4e f3 bd b1 46 78 9 a4 94 4e 1a 86 bb d9 cb 34 c9 97 59 5c 14 86 72 64 34 7b 2 96 ab
 66 0 b6 f1 a9 cb 3d 4a 22 5b 6 bf 2a e7 f3 9c 68 58 73 5 20 31 58 60 bd bf 14 31 2f e6 b9 18 5
 f9 38 22 77 2a a9 53 ab 4e b fe f6 b2 a6 26 dc 3 b2 3f f4 45 62 2d 64 53 f9 dd 34 f0 51
```
Time taken by better fine grained parallel: 0.022922s

neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/finalImplementation/parallel_code$

Serial :

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fina...

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...   neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...

```
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fin
alImplementation/serial_code$ g++ -fopenmp 03_better_fine_grained_serial.cpp
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fin
alImplementation/serial_code$ ./a.out
Enter the message to encrypt: Sample text for Roma : the novel of ancient Rome / Steven Saylor
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mplete or contain other coding.CounterChapter OneA Stop on the Salt Route1000 B.C.As they roun
ded a bend in the path that ran beside the river, Lara recognized the silhouette of a fig tree
 atop a nearby hill. The weather was hot and the days were long. The fig tree was in full leaf
, but not yet bearing fruit.Soon Lara spotted other landmarks—an outcropping of limestone besi
de the path that had a silhouette like a man's face, a marshy spot beside the river where the
waterfowl were easily startled, a tall tree that looked like a man with his arms upraised. The
y were drawing near to the place where there was an island in the river. The island was a good
 spot to make camp. They would sleep on the island tonight.Lara had been back and forth along
the river path many times in her short life. Her people had not created the path—it had always
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rts kept the path well worn. Lara's people were salt traders, and their livelihood took them o
n a continual journey.At the mouth of the river, the little group of half a dozen intermingled
 families gathered salt from the great salt beds beside the sea. They groomed and sifted the s
alt and loaded it into handcarts. When the carts were full, most of the group would stay behin
d, taking shelter amid rocks and simple lean-tos, while a band of fifteen or so of the heartie
r members set out on the path that ran alongside the river.With their precious cargo of salt,
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e never reached the mountaintops; they traveled only as far as the foothills.
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on Lara spotted other landmarks—an outcropping of limestone beside the path that had a silhoue
tte like a man's face, a marshy spot beside the river where the waterfowl were easily startled
, a tall tree that looked like a man with his arms upraised. They were drawing near to the pla
ce where there was an island in the river. The island was a good spot to make camp. They would
 sleep on the island tonight.Lara had been back and forth along the river path many times in h
er short life. Her people had not created the path—it had always been there, like the river—bu
t their deerskin-shod feet and the wooden wheels of their handcarts kept the path well worn. L
ara's people were salt traders, and their livelihood took them on a continual journey.At the m
outh of the river, the little group of half a dozen intermingled families gathered salt from t
he great salt beds beside the sea. They groomed and sifted the salt and loaded it into handcar
ts. When the carts were full, most of the group would stay behind, taking shelter amid rocks a
nd simple lean-tos, while a band of fifteen or so of the heartier members set out on the path
that ran alongside the river.With their precious cargo of salt, the travelers crossed the coas
tal lowlands and traveled toward the mountains. But Lara's people never reached the mountainto
ps; they traveled only as far as the foothills.
padded msg length : 1952
Time taken to AddRoundKey : 0.000297494
```

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fina...

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...   neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...

```
Time taken to SubBytes:0.000259725
Time taken to ShiftRows:0.000138305
Time taken to MixColumns:0.000242267
Encrypted message in hex:
4e 21 fc 31 e9 15 26 23 e f 15 36 62 57 e8 ad 60 b7 eb de 8b 80 fc 51 fa 54 82 18 a6 73 8 8c d
9 a3 fc 10 79 99 e6 d5 ee ea fb eb ba c3 ca 64 85 6f cf 48 6f 6a 6c 8c c7 e 13 cd 4 fa 91 54 8
0 48 b3 81 6b c3 7b b2 a2 a5 13 ea f0 de 91 ab a 72 da 76 d7 b9 ac 10 91 6b 22 2c d9 5 eb bc 2
a b3 9c f a 79 22 4f 2 5e 47 ed a5 1 df 7c dc 30 c8 ba b9 ea e8 7 70 c8 76 6b c4 b8 45 7d a7 5
5 91 98 c 2a 92 fa 8d 81 ab a2 9d 9 d1 85 75 bc 30 26 ba 93 69 6f 78 5 57 52 64 15 ae ac 53 33
 df 64 9 40 9c ca 6a 77 af c1 f9 ab 65 84 c1 4d 39 c 6d 12 7a 1e d7 f0 c2 eb b9 97 3f ab f0 cc
 d8 56 df 6c 56 84 a6 40 fa 32 65 8f 22 30 85 8c 2d d8 94 aa ff af fb db 77 35 f6 89 22 df d6
85 18 1 5b 63 b5 57 13 c0 ae 7 62 98 3c 6 7a 9a 8a 44 e6 e5 85 78 a 6a 8a 82 3 75 f8 3b c3 1c
cc 88 a7 c0 36 90 32 3 90 5e 4 d4 88 95 54 7c 79 2d 2f b6 53 fd 23 53 41 f0 a0 9e 8f cc b5 f8
3c 50 e7 be 30 5b a6 b3 1d fb a8 39 15 d4 a5 cd d7 5f da bb 96 53 39 12 6c 5d c4 fa ec 82 5 f4
 58 90 1e e9 9 6d f9 8b fa 6f f4 28 5a 3a f6 59 70 6b c8 2f 16 8c ba 5e df 7c 7 44 5c 52 61 43
 51 65 ce 4c 8d cf d0 5f 8a a8 c4 d4 66 b0 57 c9 d4 f0 50 c0 72 96 22 ad bf d1 37 73 cb 64 87
22 fb a9 6c 6d 30 bb 3 ca 3b 18 8c d7 83 aa 15 ee ae 28 a7 6f ba f2 a0 b3 bc a7 5e 2 54 66 d7
58 5f eb fe 25 aa ba fd 4d 66 15 9d 99 e4 60 d3 1c f3 6b 5b d7 e4 27 4b 3 61 78 bd 11 eb 7b 85
 d7 bf a2 47 51 91 4c 4b 67 87 8a d2 f0 2e 71 9a 6a 80 1a ea 27 90 30 b9 ee e2 7f a3 ae df 17
55 4d ca b0 73 4c 31 1b a3 39 ae fd 61 c0 7c 8a 21 a 13 2b 7a 1 9f 71 e5 c2 c5 55 69 89 d2 56
dd d0 d4 ea 3b 8 e5 74 6a 8f e 74 ed a3 f4 68 3b e4 18 3e 81 34 56 fe e9 42 ec 34 76 ec d a2 f
9 c0 33 56 96 77 dd 29 6a de f9 f0 20 ec 6d 5c 18 2a 6a dd 7a ab 90 a0 2c 3b d0 d8 4e 7d d4 86
 68 67 6f 64 de e 88 90 63 e7 b5 4c 7 d1 54 e 44 81 7d eb 47 d2 b0 cc d6 ff 39 b0 43 51 87 3a
34 90 1f 5d 71 f 60 bd 75 30 e9 36 ad a8 37 c 51 e4 69 d7 b f8 ee 58 76 fc 5e e2 9f fc dc 8f 7
3 af f4 f3 3f b2 3d 6b 7a d7 95 42 dd 54 b2 b9 ea 73 86 96 d4 26 26 f1 df 60 c8 74 fe 44 89 38
 94 18 20 94 88 3 52 e2 a1 d0 40 9c 71 f7 1e 29 a0 f 45 23 eb 2a 73 4 6c 8c 3d c0 2c e9 67 c3
ed 72 7d e6 31 cc a3 9d d3 ef 71 f4 fb 40 87 b6 99 7a 5c b2 f2 5c 28 e9 c2 72 56 30 da 88 5a 8
f fa d8 70 67 f9 21 5a 56 dc 4a 90 b9 72 7b 14 4d 55 b0 cd c5 33 9a e6 3b 6a 68 9c 1b a2 34 db
 8c 23 c7 30 fc 69 e9 ca ef 77 e0 a3 70 5c 6d cf 17 97 c2 d5 1 4b 99 ce 89 b1 30 c5 3 df 12 41
 76 31 f3 54 34 ea 2d 78 94 23 77 85 4d 4f 71 45 99 5c 42 aa a4 43 62 ad bd 5b 51 14 d4 2a eb
27 2e 62 e5 8a 46 88 98 3f 80 c4 4c e1 2e cc f9 38 97 41 e7 a0 44 f9 84 e5 c9 a8 62 f3 f0 1e 8
d 10 da 89 38 28 c6 8b c3 fd dc 8f 3c 40 51 cd 38 bb f2 de 4 1b ed 18 bc 37 5 a4 cd 4c 50 dd c
c de fa 88 4b 88 b6 bd 1c 48 31 3e 55 8f f9 28 ee 96 4a 25 5 2c c8 cc 63 4c 1a 4a 6f aa a cd 1
3 91 8f 93 3b 8f 7 0 e7 7c f8 5c ab 3e e7 c6 8c b 63 a7 34 f6 dc ef d1 f3 81 7b 7f dd f7 cd 88
 67 0 b9 ea f0 c3 a8 49 64 d5 65 19 8e a9 3c 7e f4 ee e6 b7 50 4f 0 74 bd 81 66 ce 26 c5 93 1a
 c4 ea 41 90 a4 f7 26 db fa 28 f7 4f e6 e9 4e 15 b5 5c b0 26 16 f2 32 28 bf 45 2c 7a 1d ef 58
2d ff 66 c5 92 dc d6 78 59 55 13 62 f9 c7 97 99 b2 46 18 59 e3 e6 7e 78 e7 64 c1 c1 e3 58 6b 5
7 9c 1b cb 86 94 e3 d 27 d8 89 b5 b e4 ae 57 41 e0 d3 bf 61 97 6d 90 c5 8a d0 5b 7d 2d 3b 31 d
4 54 fa da 6e b4 33 6e 10 56 7a b7 af c4 d0 4f 2e c1 c7 ee b7 46 a7 ab ef 2 52 d9 99 3a d4 89
da 2a 38 c9 88 94 7d 7e 8f c3 e4 fa 9c 98 9c b7 b8 3b 81 fd 7d fd f4 d9 8 c 15 de 66 4b c3 19
d4 c4 bc d4 b6 54 98 8d bd d1 5f 26 ba 1 47 ea fa 19 37 95 32 e3 ee b3 f8 2a 70 39 f4 28 81 6
22 43 88 3a 3f aa f0 3b 44 22 b6 f9 f5 30 f bf 66 ea 79 95 39 4f 79 95 b 4b c8 8c 64 97 90 c4
f2 1a 4e be df 83 9e 91 4f 42 db 72 ff 43 75 f9 a8 ba 7 fa b4 74 ba 91 40 b3 bb 3e 60 93 51 c1
 37 77 aa e5 59 ac 65 5e 21 cb c8 99 ea c1 b8 a4 40 e2 e4 be 9b 90 95 b5 8e fb d1 b8 f7 da d 1
3 1d b6 94 d7 90 5a 11 cf 14 8d 92 9c 35 86 f1 85 4d cd e 29 6 f4 31 d3 ee 51 7e 36 69 9c 2b a
c cb bc c5 42 a4 a1 67 93 ab bb 31 73 8c 1d ae aa 89 4f f1 65 af d9 9 1 48 b6 1b 42 2 13 43 af
 14 25 a6 3a 73 49 31 c6 b4 f0 28 da 36 59 cc 7 cc b2 b9 f5 c 60 78 32 f4 dd 5 fe 97 34 4f e2
15 ab b8 8d f2 6e 33 e4 c8 2 b3 8c cf ba ef 7d 47 ba 44 2f 5 64 dc 45 f9 3c cd 99 35 84 3 4c 9
```

```
f f9 dd 56 fb 99 cf 5c e 74 99 7a f0 41 3 35 0 c3 1b 69 52 f0 c3 17 89 1a c5 23 c0 d7 ce e7 b7
 37 3a 2c 70 49 6e 51 dd f1 7a 83 2b de c2 e5 1d 92 95 7a 6c b1 e8 ea b8 7d 4d 5e 33 bb d6 70
5e 2c ef a9 bc 97 b6 a7 eb a8 49 d9 48 c1 8d 43 a2 95 2c 7c 1 6f 39 33 32 bd 3d fe 27 1 1c 6d
33 8 cb 1b e4 9 4b ad f4 9 9b c4 ca 86 ab 9e af 9d e a5 fb ea 3d 28 57 a5 da c5 a1 ff d9 9d 2
67 2b 48 59 bb a9 62 9 43 ca d9 27 c1 f2 45 aa 93 34 fc 48 cf 93 92 b1 70 3c 33 3f 79 7e 62 6e
 56 dd 51 b2 2b 7b 7a 52 6 c d7 f7 1e a5 53 90 2b 19 25 7f aa be 1b d3 43 27 d3 14 88 f3 ea f4
 80 c 39 a0 d8 9a 8c 4b 45 ef fa 1b 8 d0 9 1 4a 47 9d 7a 3b 20 90 9e 27 f1 4e 5b 2b 5e da 3 99
 9f f5 69 7c 91 4a ed 14 e2 1f 6e 91 39 4a 7c 85 ab df 94 f8 ae 55 f0 f0 e9 34 a9 3c 64 87 4f
1c 40 7b 9c b 91 b4 c9 51 7b cd 63 d2 8a 47 d8 eb a2 ae 6e b4 be fa 4f a 1d d4 81 af f8 e4 ca
3c 2d a0 d3 53 68 4f 7e 75 5a c9 6d 6c dc 39 97 4c 70 6e 5c b9 79 7d 52 2b ac 4e bc 65 1c 1e f
1 cd 92 12 fb 72 90 3d 56 c5 2e 39 21 0 70 3a e9 14 47 eb bb d8 fe 94 f0 32 46 8b 48 3c 14 cf
1 b2 d3 b4 d7 84 4a 76 7d 2e 24 49 8e 16 94 fc 0 de 39 7 ea 2c 13 6d b1 47 ae 32 2c 43 89 db 1
c 9e 6 f9 d 11 b 10 fe 77 4 8 19 4e a2 4b ee 25 ac bb a7 d9 41 f b3 96 5c 76 3b 85 2 3 31 3f 5
e a 5a 4d 35 79 b0 6e 42 be e1 d8 a ca 38 56 d2 c5 fa 9f ea fa ff a3 c6 29 ec 12 ba fe b3 e8 4
3 c5 3d 12 7b 4a 86 4b 60 36 30 1d 8e 14 b7 3b 9f e5 8e 5a 7d 5 24 fe 5f cc 67 a 11 c4 71 44 2
7 9c 90 60 38 c7 3a 7b 24 ce e6 29 9c d9 4 2e fb 24 f3 ef 1c cf e8 28 47 89 56 ed f0 ef 37 9c
f0 9e 7d 3d 9d 3b 9d c2 bd 80 d2 4d bd 9a c3 b7 6d d1 4b 13 7 fe a9 e2 81 a9 4d 4d 77 f7 d 9c
ad 32
Time taken by better fine grained serial: 0.003092s
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/fin
alImplementation/serial_code$
```

6.1.6. Modular Exponentiation

Parallel :

```
neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/5_o...

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...    ×    neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...    ×

neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/5_o
wn_omp_parallel-squaremultiply/parallel_code$ g++ -fopenmp 01_sm_parallel_try1.cpp
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/5_o
wn_omp_parallel-squaremultiply/parallel_code$ ./a.out
3 50 100
[TID:3] powM(3,1,100)
[TID:2] powM(3,25,100)
[TID:1] powM(3,6,100)
[TID:0] powM(3,50,100)
49
[TID:7] powM(3,12,100)
[TID:5] powM(3,3,100)
Time taken to find modular exponent  :0.00323932
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/5_o
wn_omp_parallel-squaremultiply/parallel_code$
```

Serial :

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/5_o...

neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...   ×   neelchoksi19bce0990@neel: ~/Documents/NeelVITCurrSem/se...   ×

```
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/5_o
wn_omp_parallel-squaremultiply$ g++ -fopenmp 01_sm_try1.cpp
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/5_o
wn_omp_parallel-squaremultiply$ ./a.out
3 50 100
49
Time taken to find modular exponent  :5.4849e-05
neelchoksi19bce0990@neel:~/Documents/NeelVITCurrSem/sem6/proj/cse4001/PDC_Project_SEM6_VIT/5_o
wn_omp_parallel-squaremultiply$
```