ASSIGNMENT REPORT

APPLIED CRYPTOGRAPHY (CS-6530), IIT MADRAS
Designing and Implementing a Block Cipher Similar to AES
(Final Submission)

Faculty

Asst Prof. Chester Rebeiro

Members

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Vivek Kumar Agrawal (CS17M049)

12. Implement your complete cipher as efficiently as possible. Some implementation options for high speed include (1) using T-tables (refer OpenSSL implementations as studied in class), (2) using bit slicing (refer to this paper: bitslice implementations of AES).

The implementation of the cipher **CLONE** that was submitted earlier was modified through the usage of T-tables for increasing the efficiency. The undermentioned 4 T-tables were used:

```
T0[256] = {
0x00000000, 0x02010103, 0x04020206, 0x06030305,
0x0804040c, 0x0a05050f, 0x0c06060a, 0x0e070709,
0x10080818, 0x1209091b, 0x140a0a1e, 0x160b0b1d,
0x180c0c14, 0x1a0d0d17, 0x1c0e0e12, 0x1e0f0f11,
0x20101030, 0x22111133, 0x24121236, 0x26131335,
0x2814143c, 0x2a15153f, 0x2c16163a, 0x2e171739,
0x30181828, 0x3219192b, 0x341a1a2e, 0x361b1b2d,
0x381c1c24, 0x3a1d1d27, 0x3c1e1e22, 0x3e1f1f21,
0x40202060, 0x42212163, 0x44222266, 0x46232365,
0x4824246c, 0x4a25256f, 0x4c26266a, 0x4e272769,
0x50282878, 0x5229297b, 0x542a2a7e, 0x562b2b7d,
0x582c2c74, 0x5a2d2d77, 0x5c2e2e72, 0x5e2f2f71,
0x60303050, 0x62313153, 0x64323256, 0x66333355,
0x6834345c, 0x6a35355f, 0x6c36365a, 0x6e373759,
0x70383848, 0x7239394b, 0x743a3a4e, 0x763b3b4d,
0x783c3c44, 0x7a3d3d47, 0x7c3e3e42, 0x7e3f3f41,
0x804040c0, 0x824141c3, 0x844242c6, 0x864343c5,
0x884444cc, 0x8a4545cf, 0x8c4646ca, 0x8e4747c9,
0x904848d8, 0x924949db, 0x944a4ade, 0x964b4bdd,
0x984c4cd4, 0x9a4d4dd7, 0x9c4e4ed2, 0x9e4f4fd1,
0xa05050f0, 0xa25151f3, 0xa45252f6, 0xa65353f5,
0xa85454fc, 0xaa5555ff, 0xac5656fa, 0xae5757f9,
0xb05858e8, 0xb25959eb, 0xb45a5aee, 0xb65b5bed,
0xb85c5ce4, 0xba5d5de7, 0xbc5e5ee2, 0xbe5f5fe1,
0xc06060a0, 0xc26161a3, 0xc46262a6, 0xc66363a5,
0xc86464ac, 0xca6565af, 0xcc6666aa, 0xce6767a9,
0xd06868b8, 0xd26969bb, 0xd46a6abe, 0xd66b6bbd,
0xd86c6cb4, 0xda6d6db7, 0xdc6e6eb2, 0xde6f6fb1,
0xe0707090, 0xe2717193, 0xe4727296, 0xe6737395,
0xe874749c, 0xea75759f, 0xec76769a, 0xee777799,
0xf0787888, 0xf279798b, 0xf47a7a8e, 0xf67b7b8d,
0xf87c7c84, 0xfa7d7d87, 0xfc7e7e82, 0xfe7f7f81,
0xcf80804f, 0xcd81814c, 0xcb828249, 0xc983834a,
0xc7848443, 0xc5858540, 0xc3868645, 0xc1878746,
0xdf888857, 0xdd898954, 0xdb8a8a51, 0xd98b8b52,
0xd78c8c5b, 0xd58d8d58, 0xd38e8e5d, 0xd18f8f5e,
0xef90907f, 0xed91917c, 0xeb929279, 0xe993937a,
0xe7949473, 0xe5959570, 0xe3969675, 0xe1979776,
0xff989867, 0xfd999964, 0xfb9a9a61, 0xf99b9b62,
0xf79c9c6b, 0xf59d9d68, 0xf39e9e6d, 0xf19f9f6e,
0x8fa0a02f, 0x8da1a12c, 0x8ba2a229, 0x89a3a32a,
0x87a4a423, 0x85a5a520, 0x83a6a625, 0x81a7a726,
0x9fa8a837, 0x9da9a934, 0x9baaaa31, 0x99abab32,
0x97acac3b, 0x95adad38, 0x93aeae3d, 0x91afaf3e,
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0xafb0b01f, 0xadb1b11c, 0xabb2b219, 0xa9b3b31a,
0xa7b4b413, 0xa5b5b510, 0xa3b6b615, 0xa1b7b716,
0xbfb8b807, 0xbdb9b904, 0xbbbaba01, 0xb9bbbb02,
0xb7bcbc0b, 0xb5bdbd08, 0xb3bebe0d, 0xb1bfbf0e,
0x4fc0c08f, 0x4dc1c18c, 0x4bc2c289, 0x49c3c38a,
0x47c4c483, 0x45c5c580, 0x43c6c685, 0x41c7c786,
0x5fc8c897, 0x5dc9c994, 0x5bcaca91, 0x59cbcb92,
0x57cccc9b, 0x55cdcd98, 0x53cece9d, 0x51cfcf9e,
0x6fd0d0bf, 0x6dd1d1bc, 0x6bd2d2b9, 0x69d3d3ba,
0x67d4d4b3, 0x65d5d5b0, 0x63d6d6b5, 0x61d7d7b6,
0x7fd8d8a7, 0x7dd9d9a4, 0x7bdadaa1, 0x79dbdba2,
0x77dcdcab, 0x75ddda8, 0x73dedead, 0x71dfdfae,
0x0fe0e0ef, 0x0de1e1ec, 0x0be2e2e9, 0x09e3e3ea,
0x07e4e4e3, 0x05e5e5e0, 0x03e6e6e5, 0x01e7e7e6,
0x1fe8e8f7, 0x1de9e9f4, 0x1beaeaf1, 0x19ebebf2,
0x17ececfb, 0x15ededf8, 0x13eeeefd, 0x11efeffe,
0x2ff0f0df, 0x2df1f1dc, 0x2bf2f2d9, 0x29f3f3da,
0x27f4f4d3, 0x25f5f5d0, 0x23f6f6d5, 0x21f7f7d6,
0x3ff8f8c7, 0x3df9f9c4, 0x3bfafac1, 0x39fbfbc2,
0x37fcfccb, 0x35fdfdc8, 0x33fefecd, 0x31ffffce
}

T1[256] = {
0x00000000, 0x03020101, 0x06040202, 0x05060303,
0x0c080404, 0x0f0a0505, 0x0a0c0606, 0x090e0707,
0x18100808, 0x1b120909, 0x1e140a0a, 0x1d160b0b,
0x14180c0c, 0x171a0d0d, 0x121c0e0e, 0x111e0f0f,
0x30201010, 0x33221111, 0x36241212, 0x35261313,
0x3c281414, 0x3f2a1515, 0x3a2c1616, 0x392e1717,
0x28301818, 0x2b321919, 0x2e341a1a, 0x2d361b1b,
0x24381c1c, 0x273a1d1d, 0x223c1e1e, 0x213e1f1f,
0x60402020, 0x63422121, 0x66442222, 0x65462323,
0x6c482424, 0x6f4a2525, 0x6a4c2626, 0x694e2727,
0x78502828, 0x7b522929, 0x7e542a2a, 0x7d562b2b,
0x74582c2c, 0x775a2d2d, 0x725c2e2e, 0x715e2f2f,
0x50603030, 0x53623131, 0x56643232, 0x55663333,
0x5c683434, 0x5f6a3535, 0x5a6c3636, 0x596e3737,
0x48703838, 0x4b723939, 0x4e743a3a, 0x4d763b3b,
0x44783c3c, 0x477a3d3d, 0x427c3e3e, 0x417e3f3f,
0xc0804040, 0xc3824141, 0xc6844242, 0xc5864343,
0xcc884444, 0xcf8a4545, 0xca8c4646, 0xc98e4747,
0xd8904848, 0xdb924949, 0xde944a4a, 0xdd964b4b,
0xd4984c4c, 0xd79a4d4d, 0xd29c4e4e, 0xd19e4f4f,
0xf0a05050, 0xf3a25151, 0xf6a45252, 0xf5a65353,
0xfca85454, 0xffaa5555, 0xfaac5656, 0xf9ae5757,
0xe8b05858, 0xebb25959, 0xeeb45a5a, 0xedb65b5b,
0xe4b85c5c, 0xe7ba5d5d, 0xe2bc5e5e, 0xe1be5f5f,
0xa0c06060, 0xa3c26161, 0xa6c46262, 0xa5c66363,
0xacc86464, 0xafca6565, 0xaacc6666, 0xa9ce6767,
0xb8d06868, 0xbbd26969, 0xbed46a6a, 0xbdd66b6b,
0xb4d86c6c, 0xb7da6d6d, 0xb2dc6e6e, 0xb1de6f6f,
0x90e07070, 0x93e27171, 0x96e47272, 0x95e67373,
0x9ce87474, 0x9fea7575, 0x9aec7676, 0x99ee7777,
0x88f07878, 0x8bf27979, 0x8ef47a7a, 0x8df67b7b,
0x84f87c7c, 0x87fa7d7d, 0x82fc7e7e, 0x81fe7f7f,
0x4fcf8080, 0x4ccd8181, 0x49cb8282, 0x4ac98383,
0x43c78484, 0x40c58585, 0x45c38686, 0x46c18787,
0x57df8888, 0x54dd8989, 0x51db8a8a, 0x52d98b8b,
0x5bd78c8c, 0x58d58d8d, 0x5dd38e8e, 0x5ed18f8f,
0x7fef9090, 0x7ced9191, 0x79eb9292, 0x7ae99393,
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0x73e79494, 0x70e59595, 0x75e39696, 0x76e19797,
0x67ff9898, 0x64fd9999, 0x61fb9a9a, 0x62f99b9b,
0x6bf79c9c, 0x68f59d9d, 0x6df39e9e, 0x6ef19f9f,
0x2f8fa0a0, 0x2c8da1a1, 0x298ba2a2, 0x2a89a3a3,
0x2387a4a4, 0x2085a5a5, 0x2583a6a6, 0x2681a7a7,
0x379fa8a8, 0x349da9a9, 0x319baaaa, 0x3299abab,
0x3b97acac, 0x3895adad, 0x3d93aeae, 0x3e91afaf,
0x1fafb0b0, 0x1cadb1b1, 0x19abb2b2, 0x1aa9b3b3,
0x13a7b4b4, 0x10a5b5b5, 0x15a3b6b6, 0x16a1b7b7,
0x07bfb8b8, 0x04bdb9b9, 0x01bbbaba, 0x02b9bbbb,
0x0bb7bcbc, 0x08b5bdbd, 0x0db3bebe, 0x0eb1bfbf,
0x8f4fc0c0, 0x8c4dc1c1, 0x894bc2c2, 0x8a49c3c3,
0x8347c4c4, 0x8045c5c5, 0x8543c6c6, 0x8641c7c7,
0x975fc8c8, 0x945dc9c9, 0x915bcaca, 0x9259cbcb,
0x9b57cccc, 0x9855cdcd, 0x9d53cece, 0x9e51cfcf,
0xbf6fd0d0, 0xbc6dd1d1, 0xb96bd2d2, 0xba69d3d3,
0xb367d4d4, 0xb065d5d5, 0xb563d6d6, 0xb661d7d7,
0xa77fd8d8, 0xa47dd9d9, 0xa17bdada, 0xa279dbdb,
0xab77dcdc, 0xa875dddd, 0xad73dede, 0xae71dfdf,
0xef0fe0e0, 0xec0de1e1, 0xe90be2e2, 0xea09e3e3,
0xe307e4e4, 0xe005e5e5, 0xe503e6e6, 0xe601e7e7,
0xf71fe8e8, 0xf41de9e9, 0xf11beaea, 0xf219ebeb,
0xfb17ecec, 0xf815eded, 0xfd13eeee, 0xfe11efef,
0xdf2ff0f0, 0xdc2df1f1, 0xd92bf2f2, 0xda29f3f3,
0xd327f4f4, 0xd025f5f5, 0xd523f6f6, 0xd621f7f7,
0xc73ff8f8, 0xc43df9f9, 0xc13bfafa, 0xc239fbfb,
0xcb37fcfc, 0xc835fdfd, 0xcd33fefe, 0xce31ffff
}

T2[256] = {
0x00000000, 0x01030201, 0x02060402, 0x03050603,
0x040c0804, 0x050f0a05, 0x060a0c06, 0x07090e07,
0x08181008, 0x091b1209, 0x0a1e140a, 0x0b1d160b,
0x0c14180c, 0x0d171a0d, 0x0e121c0e, 0x0f111e0f,
0x10302010, 0x11332211, 0x12362412, 0x13352613,
0x143c2814, 0x153f2a15, 0x163a2c16, 0x17392e17,
0x18283018, 0x192b3219, 0x1a2e341a, 0x1b2d361b,
0x1c24381c, 0x1d273a1d, 0x1e223c1e, 0x1f213e1f,
0x20604020, 0x21634221, 0x22664422, 0x23654623,
0x246c4824, 0x256f4a25, 0x266a4c26, 0x27694e27,
0x28785028, 0x297b5229, 0x2a7e542a, 0x2b7d562b,
0x2c74582c, 0x2d775a2d, 0x2e725c2e, 0x2f715e2f,
0x30506030, 0x31536231, 0x32566432, 0x33556633,
0x345c6834, 0x355f6a35, 0x365a6c36, 0x37596e37,
0x38487038, 0x394b7239, 0x3a4e743a, 0x3b4d763b,
0x3c44783c, 0x3d477a3d, 0x3e427c3e, 0x3f417e3f,
0x40c08040, 0x41c38241, 0x42c68442, 0x43c58643,
0x44cc8844, 0x45cf8a45, 0x46ca8c46, 0x47c98e47,
0x48d89048, 0x49db9249, 0x4ade944a, 0x4bdd964b,
0x4cd4984c, 0x4dd79a4d, 0x4ed29c4e, 0x4fd19e4f,
0x50f0a050, 0x51f3a251, 0x52f6a452, 0x53f5a653,
0x54fca854, 0x55ffaa55, 0x56faac56, 0x57f9ae57,
0x58e8b058, 0x59ebb259, 0x5aeeb45a, 0x5bedb65b,
0x5ce4b85c, 0x5de7ba5d, 0x5ee2bc5e, 0x5fe1be5f,
0x60a0c060, 0x61a3c261, 0x62a6c462, 0x63a5c663,
0x64acc864, 0x65afca65, 0x66aacc66, 0x67a9ce67,
0x68b8d068, 0x69bbd269, 0x6abed46a, 0x6bbdd66b,
0x6cb4d86c, 0x6db7da6d, 0x6eb2dc6e, 0x6fb1de6f,
0x7090e070, 0x7193e271, 0x7296e472, 0x7395e673,
0x749ce874, 0x759fea75, 0x769aec76, 0x7799ee77,
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0x7888f078, 0x798bf279, 0x7a8ef47a, 0x7b8df67b,
0x7c84f87c, 0x7d87fa7d, 0x7e82fc7e, 0x7f81fe7f,
0x804fcf80, 0x814ccd81, 0x8249cb82, 0x834ac983,
0x8443c784, 0x8540c585, 0x8645c386, 0x8746c187,
0x8857df88, 0x8954dd89, 0x8a51db8a, 0x8b52d98b,
0x8c5bd78c, 0x8d58d58d, 0x8e5dd38e, 0x8f5ed18f,
0x907fef90, 0x917ced91, 0x9279eb92, 0x937ae993,
0x9473e794, 0x9570e595, 0x9675e396, 0x9776e197,
0x9867ff98, 0x9964fd99, 0x9a61fb9a, 0x9b62f99b,
0x9c6bf79c, 0x9d68f59d, 0x9e6df39e, 0x9f6ef19f,
0xa02f8fa0, 0xa12c8da1, 0xa2298ba2, 0xa32a89a3,
0xa42387a4, 0xa52085a5, 0xa62583a6, 0xa72681a7,
0xa8379fa8, 0xa9349da9, 0xaa319baa, 0xab3299ab,
0xac3b97ac, 0xad3895ad, 0xae3d93ae, 0xaf3e91af,
0xb01fafb0, 0xb11cadb1, 0xb219abb2, 0xb31aa9b3,
0xb413a7b4, 0xb510a5b5, 0xb615a3b6, 0xb716a1b7,
0xb807bfb8, 0xb904bdb9, 0xba01bbba, 0xbb02b9bb,
0xbc0bb7bc, 0xbd08b5bd, 0xbe0db3be, 0xbf0eb1bf,
0xc08f4fc0, 0xc18c4dc1, 0xc2894bc2, 0xc38a49c3,
0xc48347c4, 0xc58045c5, 0xc68543c6, 0xc78641c7,
0xc8975fc8, 0xc9945dc9, 0xca915bca, 0xcb9259cb,
0xcc9b57cc, 0xcd9855cd, 0xce9d53ce, 0xcf9e51cf,
0xd0bf6fd0, 0xd1bc6dd1, 0xd2b96bd2, 0xd3ba69d3,
0xd4b367d4, 0xd5b065d5, 0xd6b563d6, 0xd7b661d7,
0xd8a77fd8, 0xd9a47dd9, 0xdaa17bda, 0xdba279db,
0xdcab77dc, 0xdda875dd, 0xdead73de, 0xdfae71df,
0xe0ef0fe0, 0xe1ec0de1, 0xe2e90be2, 0xe3ea09e3,
0xe4e307e4, 0xe5e005e5, 0xe6e503e6, 0xe7e601e7,
0xe8f71fe8, 0xe9f41de9, 0xeaf11bea, 0xebf219eb,
0xecfb17ec, 0xedf815ed, 0xeefd13ee, 0xeffe11ef,
0xf0df2ff0, 0xf1dc2df1, 0xf2d92bf2, 0xf3da29f3,
0xf4d327f4, 0xf5d025f5, 0xf6d523f6, 0xf7d621f7,
0xf8c73ff8, 0xf9c43df9, 0xfac13bfa, 0xfbc239fb,
0xfccb37fc, 0xfdc835fd, 0xfecd33fe, 0xffce31ff
}

T3[256] = {
0x00000000, 0x01010302, 0x02020604, 0x03030506,
0x04040c08, 0x05050f0a, 0x06060a0c, 0x0707090e,
0x08081810, 0x09091b12, 0x0a0a1e14, 0x0b0b1d16,
0x0c0c1418, 0x0d0d171a, 0x0e0e121c, 0x0f0f111e,
0x10103020, 0x11113322, 0x12123624, 0x13133526,
0x14143c28, 0x15153f2a, 0x16163a2c, 0x1717392e,
0x18182830, 0x19192b32, 0x1a1a2e34, 0x1b1b2d36,
0x1c1c2438, 0x1d1d273a, 0x1e1e223c, 0x1f1f213e,
0x20206040, 0x21216342, 0x22226644, 0x23236546,
0x24246c48, 0x25256f4a, 0x26266a4c, 0x2727694e,
0x28287850, 0x29297b52, 0x2a2a7e54, 0x2b2b7d56,
0x2c2c7458, 0x2d2d775a, 0x2e2e725c, 0x2f2f715e,
0x30305060, 0x31315362, 0x32325664, 0x33335566,
0x34345c68, 0x35355f6a, 0x36365a6c, 0x3737596e,
0x38384870, 0x39394b72, 0x3a3a4e74, 0x3b3b4d76,
0x3c3c4478, 0x3d3d477a, 0x3e3e427c, 0x3f3f417e,
0x4040c080, 0x4141c382, 0x4242c684, 0x4343c586,
0x4444cc88, 0x4545cf8a, 0x4646ca8c, 0x4747c98e,
0x4848d890, 0x4949db92, 0x4a4ade94, 0x4b4bdd96,
0x4c4cd498, 0x4d4dd79a, 0x4e4ed29c, 0x4f4fd19e,
0x5050f0a0, 0x5151f3a2, 0x5252f6a4, 0x5353f5a6,
0x5454fca8, 0x5555ffaa, 0x5656faac, 0x5757f9ae,
0x5858e8b0, 0x5959ebb2, 0x5a5aeeb4, 0x5b5bedb6,
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0x5c5ce4b8, 0x5d5de7ba, 0x5e5ee2bc, 0x5f5fe1be,
0x6060a0c0, 0x6161a3c2, 0x6262a6c4, 0x6363a5c6,
0x6464acc8, 0x6565afca, 0x6666aacc, 0x6767a9ce,
0x6868b8d0, 0x6969bbd2, 0x6a6abed4, 0x6b6bbdd6,
0x6c6cb4d8, 0x6d6db7da, 0x6e6eb2dc, 0x6f6fb1de,
0x707090e0, 0x717193e2, 0x727296e4, 0x737395e6,
0x74749ce8, 0x75759fea, 0x76769aec, 0x777799ee,
0x787888f0, 0x79798bf2, 0x7a7a8ef4, 0x7b7b8df6,
0x7c7c84f8, 0x7d7d87fa, 0x7e7e82fc, 0x7f7f81fe,
0x80804fcf, 0x81814ccd, 0x828249cb, 0x83834ac9,
0x848443c7, 0x858540c5, 0x868645c3, 0x878746c1,
0x888857df, 0x898954dd, 0x8a8a51db, 0x8b8b52d9,
0x8c8c5bd7, 0x8d8d58d5, 0x8e8e5dd3, 0x8f8f5ed1,
0x90907fef, 0x91917ced, 0x929279eb, 0x93937ae9,
0x949473e7, 0x959570e5, 0x969675e3, 0x979776e1,
0x989867ff, 0x999964fd, 0x9a9a61fb, 0x9b9b62f9,
0x9c9c6bf7, 0x9d9d68f5, 0x9e9e6df3, 0x9f9f6ef1,
0xa0a02f8f, 0xa1a12c8d, 0xa2a2298b, 0xa3a32a89,
0xa4a42387, 0xa5a52085, 0xa6a62583, 0xa7a72681,
0xa8a8379f, 0xa9a9349d, 0xaaaa319b, 0xabab3299,
0xacac3b97, 0xadad3895, 0xaeae3d93, 0xafaf3e91,
0xb0b01faf, 0xb1b11cad, 0xb2b219ab, 0xb3b31aa9,
0xb4b413a7, 0xb5b510a5, 0xb6b615a3, 0xb7b716a1,
0xb8b807bf, 0xb9b904bd, 0xbaba01bb, 0xbbbb02b9,
0xbcbc0bb7, 0xbdbd08b5, 0xbebe0db3, 0xbfbf0eb1,
0xc0c08f4f, 0xc1c18c4d, 0xc2c2894b, 0xc3c38a49,
0xc4c48347, 0xc5c58045, 0xc6c68543, 0xc7c78641,
0xc8c8975f, 0xc9c9945d, 0xcaca915b, 0xcbcb9259,
0xcccc9b57, 0xcdcd9855, 0xcece9d53, 0xcfcf9e51,
0xd0d0bf6f, 0xd1d1bc6d, 0xd2d2b96b, 0xd3d3ba69,
0xd4d4b367, 0xd5d5b065, 0xd6d6b563, 0xd7d7b661,
0xd8d8a77f, 0xd9d9a47d, 0xdadaa17b, 0xdbdba279,
0xdcdcab77, 0xddddа875, 0xdedead73, 0xdfdfae71,
0xe0e0ef0f, 0xe1e1ec0d, 0xe2e2e90b, 0xe3e3ea09,
0xe4e4e307, 0xe5e5e005, 0xe6e6e503, 0xe7e7e601,
0xe8e8f71f, 0xe9e9f41d, 0xeaeaf11b, 0xebebf219,
0xececfb17, 0xededf815, 0xeeeefd13, 0xefeffe11,
0xf0f0df2f, 0xf1f1dc2d, 0xf2f2d92b, 0xf3f3da29,
0xf4f4d327, 0xf5f5d025, 0xf6f6d523, 0xf7f7d621,
0xf8f8c73f, 0xf9f9c43d, 0xfafac13b, 0xfbfbc239
}
```

The following code was used for the T-table lookup operation which enhanced the efficiency preventing the time consumed towards the mix-column operation that was performed earlier:

```
void t_mixCol(){
    int i,j;
    unsigned int res[4][4];
    for(i=0;i<4;i++)
              {
             for(j=0;j<4;j++){
                 if(i==0)
             res[i][j] = (T0[state[0][j]]>>24) ^ (T1[state[1][j]]>>24) ^
(T2[state[2][j]]>>24) ^ (T3[state[3][j]]>>24);
                 if(i==1)
             res[i][j] = (T0[state[0][j]]>>16 & 0xff) ^ (T1[state[1][j]]>>16 & 0xff) ^
(T2[state[2][j]]>>16 & 0xff) ^ (T3[state[3][j]]>>16 & 0xff);
```

```
                if(i==2)
            res[i][j] = (T0[state[0][j]]>>8 & 0xff) ^ (T1[state[1][j]]>>8 & 0xff) ^
(T2[state[2][j]]>>8 & 0xff) ^ (T3[state[3][j]]>>8 & 0xff);
                if(i==3)
            res[i][j] = (T0[state[0][j]] & 0xff) ^ (T1[state[1][j]] & 0xff) ^
(T2[state[2][j]] & 0xff) ^ (T3[state[3][j]] & 0xff);

        }
              }

    for(i=0;i<4;i++)
       for(j=0;j<4;j++)
              state[i][j] = res[i][j];
}
```

13. Evaluate your cipher with respect to AES to encrypt the file alice.txt.

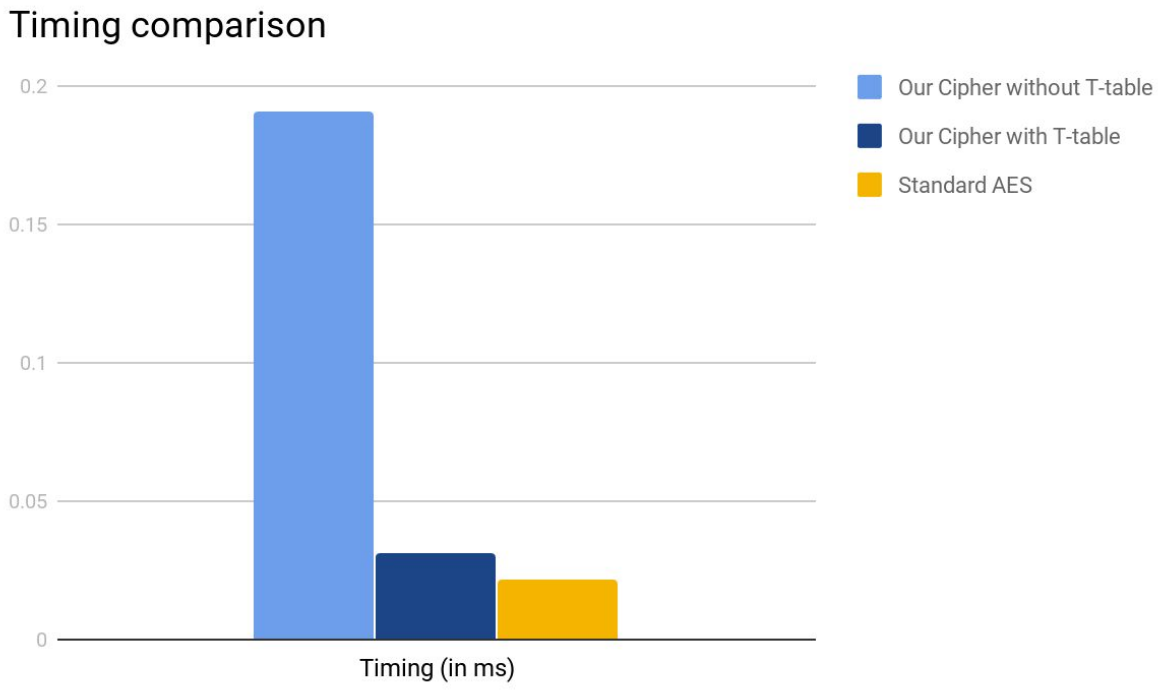
The encryption of the file alice.txt was performed under the given parameters with different implementation:

(a) **TIMING COMPARISON**

The timing of our cipher:

1. Without T-table **0.191 ms**
2. With T-table **0.031 ms**

Standard AES with openSSL was found to take **0.022ms**.



(b) **CPU USAGE COMPARISON**

Standard AES:

```
User time (seconds): 0.00
System time (seconds): 0.00
Percent of CPU this job got: 18%
Elapsed (wall clock) time (h:mm:ss or m:ss): 0:00.02
Average shared text size (kbytes): 0
Average unshared data size (kbytes): 0
Average stack size (kbytes): 0
Average total size (kbytes): 0
Maximum resident set size (kbytes): 1788
Average resident set size (kbytes): 0
Major (requiring I/O) page faults: 0
Minor (reclaiming a frame) page faults: 134
Voluntary context switches: 10
Involuntary context switches: 5
Swaps: 0
File system inputs: 0
File system outputs: 312
Socket messages sent: 0
Socket messages received: 0
Signals delivered: 0
Page size (bytes): 4096
Exit status: 0
```

Our cipher without T-Table

```
User time (seconds): 0.17
System time (seconds): 0.00
Percent of CPU this job got: 92%
Elapsed (wall clock) time (h:mm:ss or m:ss): 0:00.18
Average shared text size (kbytes): 0
Average unshared data size (kbytes): 0
Average stack size (kbytes): 0
Average total size (kbytes): 0
Maximum resident set size (kbytes): 1136
Average resident set size (kbytes): 0
Major (requiring I/O) page faults: 0
Minor (reclaiming a frame) page faults: 102
Voluntary context switches: 9
Involuntary context switches: 19
Swaps: 0
File system inputs: 0
File system outputs: 176
Socket messages sent: 0
Socket messages received: 0
Signals delivered: 0
Page size (bytes): 4096
Exit status: 0
```

Our cipher with T-Table

```
User time (seconds): 0.01
System time (seconds): 0.00
Percent of CPU this job got: 53%
Elapsed (wall clock) time (h:mm:ss or m:ss): 0:00.03
Average shared text size (kbytes): 0
Average unshared data size (kbytes): 0
Average stack size (kbytes): 0
Average total size (kbytes): 0
Maximum resident set size (kbytes): 1308
Average resident set size (kbytes): 0
Major (requiring I/O) page faults: 0
Minor (reclaiming a frame) page faults: 108
Voluntary context switches: 8
Involuntary context switches: 3
Swaps: 0
File system inputs: 0
File system outputs: 176
Socket messages sent: 0
Socket messages received: 0
Signals delivered: 0
Page size (bytes): 4096
Exit status: 0
```

CPU USAGE