Application Note

CONFIDENTIAL

Sample Dynamic TA

Application Note: Software

R-Car Series, 3rd Generation

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How to Use This Manual

- **[Readers]**
  This manual is intended for engineers who develop products which use the R-Car H3/M3/M3N/E3/D3 processor.

- **[Purpose]**
  This manual is intended to give users an understanding of the functions of the R-Car H3/M3/M3N/E3/D3 processor device driver and to serve as a reference for developing hardware and software for systems that use this driver.

- **[How to Read This Manual]**
  It is assumed that the readers of this manual have general knowledge in the fields of electrical
  — engineering, logic circuits, microcontrollers, and Linux.
  → Read this manual in the order of the CONTENTS.
  — To understand the functions of a multimedia processor for R-Car H3/M3/M3N/E3/D3
  → See the R-Car H3/M3/M3N/E3/D3 User's Manual.
  — To know the electrical specifications of the multimedia processor for R-Car H3/M3/M3N/E3/D3
  → See the R-Car H3/M3/M3N/E3/D3 Data Sheet.

- **[Conventions]**
  The following symbols are used in this manual.
  Data significance: Higher digits on the left and lower digits on the right
  Note: Footnote for item marked with Note in the text
  Caution: Information requiring particular attention
  Remark: Supplementary information
  Numeric representation: Binary ... ××××, 0b××××, or ××××B
  Decimal ... ××××
  Hexadecimal ... 0x×××× or ××××H
  Data type: Double word … 64 bits
  Word … 32 bits
  Half word ... 16 bits
  Byte ... 8 bits

Table of Contents

1. Overview

1.1 Overview

This manual describes the storage operation and AES encryption or decryption using the Dynamic TA with R-Car H3/M3/M3N/E3/D3/H3e/M3e/M3Ne/E3e/D3e.
The Sample Dynamic TA to encrypt or decrypt with the secret key stored in the storage.
The secret key is created by a random number.

1.2 References

1.2.1 Standard

The following table shows the document related to module.

Table 1.1 Standards

Number	Issue	Title	Edition
1	Global Platform	TEE Client API Specification	Rev.1.1
2	Global Platform	TEE Internal Core API Specification	Rev.1.1

1.2.2 Related Document

The following table shows the document related to this module.

Table 1.2 Related documents

Number	Issue	Title	Edition
1	Renesas Electronics	Security BSP User's Manual	#0

#0：This manual refers to the latest edition.

1.3 Restrictions

Nothing.

1.4 Terminology

The following table shows the terminology related to this module.

Table 1.3 Terminology

Terms	Explanation
AES	AES is an abbreviation for Advanced Encryption Standard.
ECB	ECB is an abbreviation for Electronic Codebook.
CBC	CBC is an abbreviation for Cipher Block Chaining.
Secret Key	Common key to be used in the AES encryption or decryption.
Secure World	It is one of the security states that defined Armv8-A architecture. When in this state, the CPU can access both the Secure and Non-secure space.
Normal World	It is one of the security states that defined Armv8-A architecture. When in this state, the CPU can access only Non-secure space.
Client Application (CA)	An application running outside of the Trusted Execution Environment making use of the TEE Client API to access facilities provided by Trusted Applications inside the Trusted Execution Environment.
Trusted Application (TA)	An application running inside the Trusted Execution Environment that provides security related functionality to Client Applications outside of the TEE or to other Trusted Applications inside the Trusted Execution Environment.

2. Operating Environment

2.1 Hardware Environment

The following table lists the hardware needed to use this function.

Table 2.1 Hardware environment (R-Car H3/M3/M3N/E3/D3)

Name	Note
Evaluation Board	R-Car H3 SiP System Evaluation Board (Salvator-X/Salvator-XS) Renesas Electronics R-Car M3 SiP System Evaluation Board (Salvator-X/Salvator-XS) Renesas Electronics R-Car M3N SiP System Evaluation Board (Salvator-XS) Renesas Electronics R-Car E3 SiP System Evaluation Board (Ebisu/Ebisu-4D) Renesas Electronics R-Car D3 SiP System Evaluation Board (Draak) Renesas Electronics
Host PC 1	It is used as debugging environment. Terminal software is executed.
Host PC 2 (Linux)	TFTP server software It is used when HyperFlash is written by U-Boot or Image is downloaded.
	NFS server software It is used when File system is mounted by NFS.

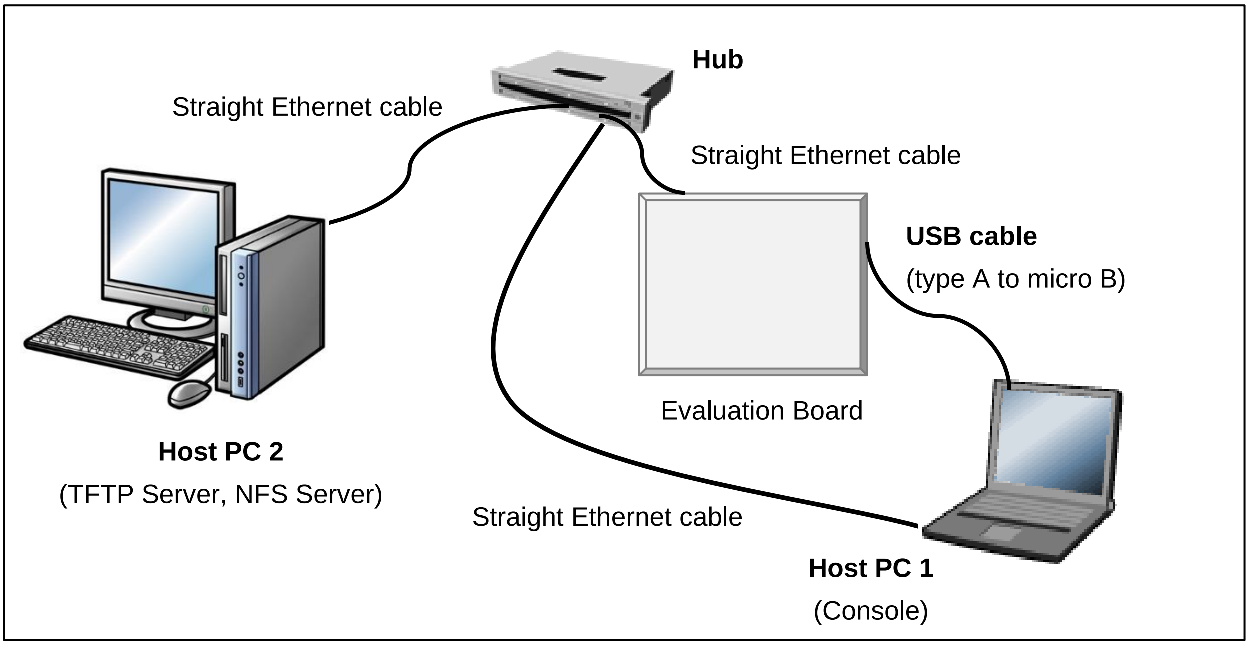


Figure 2.1 Recommended Environment

2.2 Software relationship

The following paint figure shows the description scope of Sample Dynamic TA.

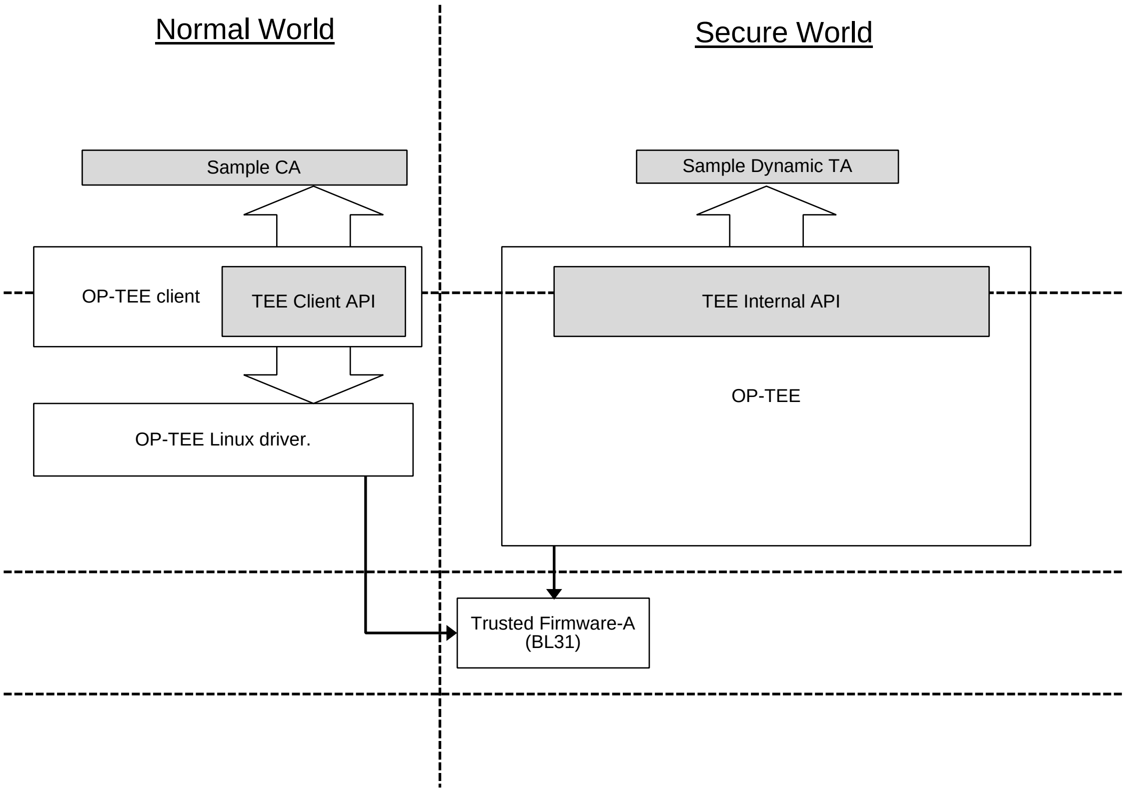


Figure 2.2 Software relationship

Table 2.2 Relationship items

Name	Note
Sample CA	Sample CA. “3.1 Function” reference for the functions that are implemented in the Sample CA.
TEE Client API	This specification defines a communications API for connecting Client Applications running in a rich operating environment with security related Trusted Applications running inside a Trusted Execution Environment (TEE). Please refer to the “TEE Client API Specification” for details.
Sample Dynamic TA	Sample Dynamic TA. “3.1 Function” reference for the functions that are implemented in the Sample Dynamic TA.
TEE Internal API	This specification defines a set of C APIs for the development of Trusted Applications (TAs) running inside a Trusted Execution Environment (TEE). Please refer to the “TEE Internal Core API Specification” for details.

3. Software

3.1 Function

This Sample Dynamic TA has the following functions.

- If the secret key does not exist in storage to create a secret key (128bit) with a random number. If the secret key is present in the storage it will use its secret key.
- Input file is encrypted or decrypted by cryptographic algorithm (ECB / CBC).
- Result of the encryption or decryption will be output to a file.

3.2 Module structure

This Sample Dynamic TA structure is shown below.

```
sampleta/                              : root directory
|-- host/
|     |-- sampleca.c                   : Source file of CA
|     `-- Makefile                     : Makefile of the CA
|-- ta/
|     |-- include/
|     |     `-- common.h               : Common definition of CA and TA
|     |-- sampleta.c                   : Source file of TA
|     |-- Makefile                     : Makefile of the CA
|     |-- sub.mk                       : Sub Makefile of the TA
|     `-- user_ta_header_defines.h     : Configurations file of the TA
`-- Makefile                           : CROSS_COMPILE of the CA and TA
```

Figure 3.1 Module structure

3.3 The processing outline of Sample Dynamic TA

The following is an outline of operation in a program.

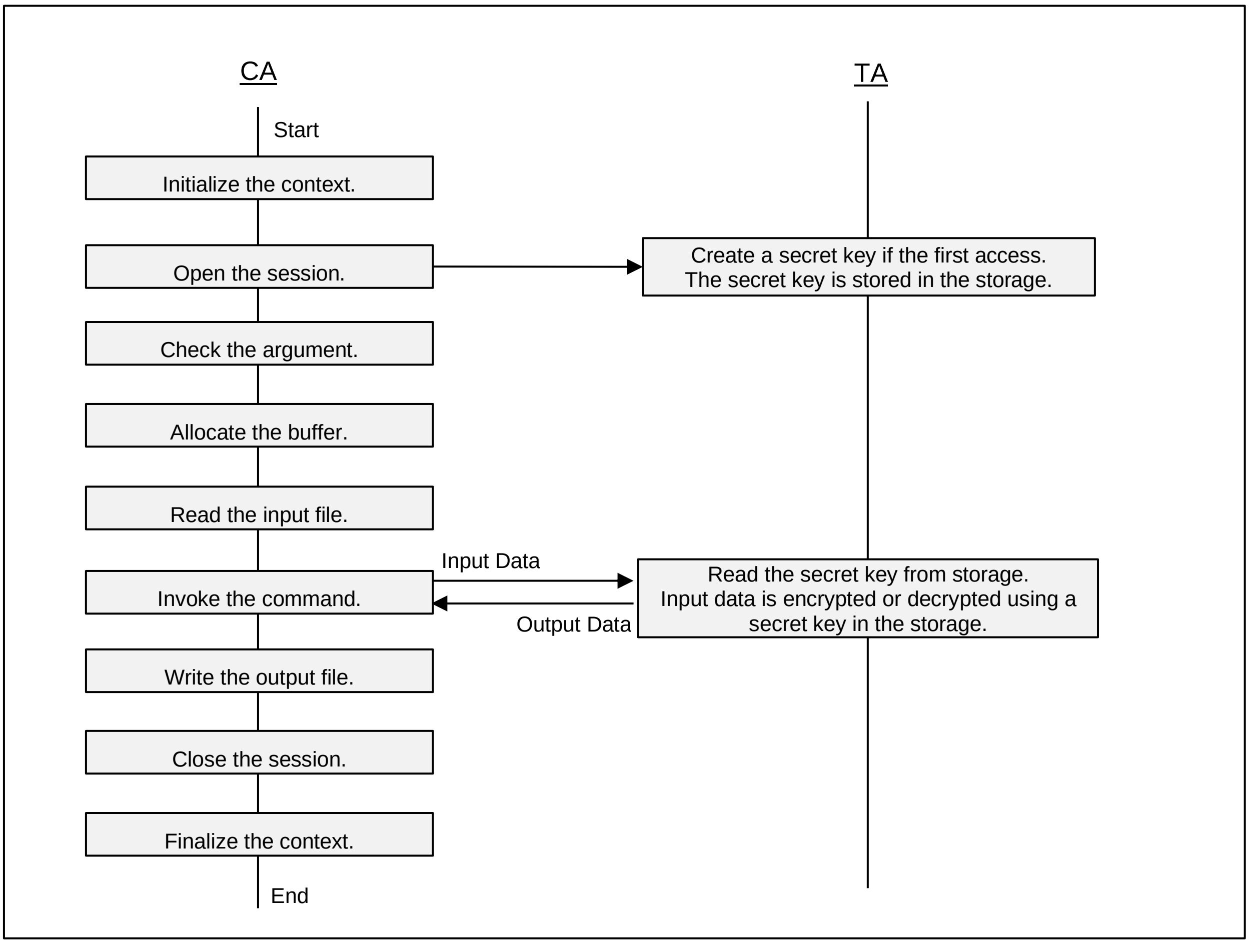


Figure 3.2 Outline of process for the Sample Dynamic TA

4. Integration

4.1 Build Sample Dynamic TA

Please acquire the sample source in the following procedures.

Step1 git clone

```
# cd $WORK
# git clone https://github.com/renesas-rcar/sampleta.git
```

Note) $WORK is the working directory.

Please refer to "4.4.3.5 How to build Dynamic TA" of the "Security BSP User's Manual" for the build procedure.
The following table shows the built output file.

Table 4.1 Output file list

Number	Application	Output path	File name
1	Sample CA	$WORK/sampleta/host/	sampleca
2	Sample Dynamic TA	$WORK/sampleta/ta/out/	2fa77580-ec0a-11e5-a47f0002a5d5c51b.ta

5. Execute the applications

This chapter shows how to perform the Sample Dynamic TA.

5.1 Execute the application

Step1 Execute application

```
# sampleca [algorithm] [mode] [input file] [output file]
```

Note) sampleca is a premise that is located in /usr/bin.

5.2 Command parameters

The following table lists the arguments that are specified by the CA.

Table 5.1 Argument

Name	Note
[algorithm]	The following parameter can be specified. ecb : AES ECB algorithm cbc : AES CBC algorithm
[mode]	The following parameter can be specified. enc : Encryption mode dec : Decryption mode
[input file]	Specify the input file. The input file is read in binary. Note) Input data must be a multiple of 16 bytes. Input data cannot be specified size larger than 262144 bytes.
[output file]	Specify the output file. The output file is written in binary.

Appendix

This chapter describes how to implement based on the sample source code.
The source is related processing colored.

Shared memory

There are two ways of how to use shared memory.

- How to copy the buffer of the CA to the shared memory.
- How to reference to the buffer pointer of the CA.

The following sample source code has entrusted the allocation of shared memory to TEE_Client_API.
output_buf has been copied to the shared memory.

```
uint8_t              *input_buf         = NULL;
uint8_t              *output_buf        = NULL;
struct               stat    st;
TEEC_SharedMemory       input_SharedMemory;
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
/* Allocates a buffer. */
if (res == (TEEC_Result)TEEC_SUCCESS) {
    input_SharedMemory.size = st.st_size;
    input_SharedMemory.flags = TEEC_MEM_INPUT;
    res = TEEC_AllocateSharedMemory(&ctx, &input_SharedMemory);
    if (res != (TEEC_Result)TEEC_SUCCESS) {
        (void)printf("TEEC_AllocateSharedMemory error 0x%08x¥n", res);
    } else {
        input_buf = input_SharedMemory.buffer;
    }
}
if (res == (TEEC_Result)TEEC_SUCCESS) {
    output_buf = malloc((size_t)st.st_size);
    if (output_buf == NULL) {
        res = TEEC_ERROR_GENERIC;
        (void)printf("Memory allocate error¥n");
    }
}
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
/* Invoke command. */
if (res == (TEEC_Result)TEEC_SUCCESS) {
    (void)memset(&op, 0, sizeof(op));
    op.paramTypes = (uint32_t)TEEC_PARAM_TYPES(TEEC_VALUE_INPUT, TEEC_VALUE_INPUT,
        TEEC_MEMREF_PARTIAL_INPUT, TEEC_MEMREF_TEMP_OUTPUT);
        op.params[0].value.a          = algo;
        op.params[1].value.a          = mode;
        op.params[2].memref.offset = 0U;
        op.params[2].memref.size      = readSize;
        op.params[2].memref.parent = &input_SharedMemory;
        op.params[3].tmpref.buffer = (void*)output_buf;
        op.params[3].tmpref.size      = readSize;

    res = TEEC_InvokeCommand(&sess, (uint32_t)E_TEEC_CRYS_CMD_AES, &op, &err_origin);
    if (res != (TEEC_Result)TEEC_SUCCESS) {
        (void)printf("TEEC_InvokeCommand failed with code 0x%08x origin 0x%08x¥n", res, err_origin);
    }
}
/* Output file */
if (res == (TEEC_Result)TEEC_SUCCESS) {
    fp_out = fopen(argv[4], "wb");
    if (fp_out == NULL) {
        (void)printf("fopen error out_file=%s¥n", argv[4]);
    } else {
        writeSize = fwrite(output_buf, 1U, op.params[3].tmpref.size, fp_out);
        (void)fclose(fp_out);

        if (writeSize != op.params[3].tmpref.size) {
            (void)printf("File write error %ld¥n", writeSize);
        }
    }
}
/* Release */
TEEC_ReleaseSharedMemory(&input_SharedMemory);
myFree(output_buf);
```

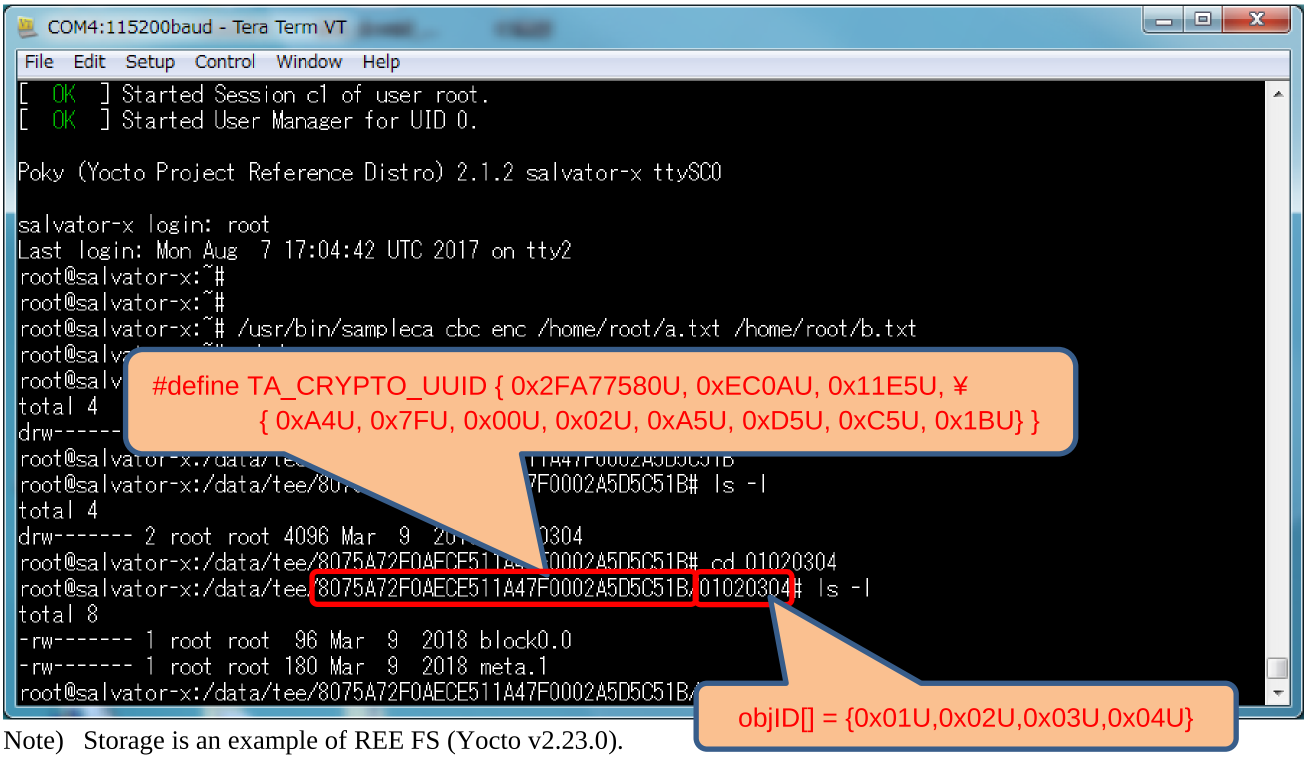
The following sample source code is then allocated on the shared memory, puts the input data to the allocated areas. Pointer of input_buf will be the address of the shared memory.

```
uint8_t             *input_buf         = NULL;
uint8_t             *output_buf        = NULL;
struct              stat    st;
TEEC_SharedMemory       input_SharedMemory;
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
/* Allocates a buffer. */
if (res == (TEEC_Result)TEEC_SUCCESS) {
      input_SharedMemory.size = st.st_size;
      input_SharedMemory.flags = TEEC_MEM_INPUT;
      res = TEEC_AllocateSharedMemory(&ctx, &input_SharedMemory);
      if (res != (TEEC_Result)TEEC_SUCCESS) {
            (void)printf("TEEC_AllocateSharedMemory error 0x%08x¥n", res);
      } else {
            input_buf = input_SharedMemory.buffer;
      }
}
if (res == (TEEC_Result)TEEC_SUCCESS) {
      output_buf = malloc((size_t)st.st_size);
      if (output_buf == NULL) {
            res = TEEC_ERROR_GENERIC;
            (void)printf("Memory allocate error¥n");
      }
}
/* Input file */
if (res == (TEEC_Result)TEEC_SUCCESS) {
      fp_in = fopen(argv[3], "rb");
      if (fp_in == NULL) {
            res = TEEC_ERROR_GENERIC;
            (void)printf("fopen error in_file=%s¥n", argv[3]);
      } else {
            readSize = fread(input_buf, 1U, (size_t)st.st_size, fp_in);
            (void)fclose(fp_in);

            if (readSize != st.st_size) {
                  res = TEEC_ERROR_GENERIC;
                  (void)printf("File read error %ld¥n", readSize);
            }
      }
}
/* Invoke command. */
if (res == (TEEC_Result)TEEC_SUCCESS) {
      (void)memset(&op, 0, sizeof(op));
      op.paramTypes = (uint32_t)TEEC_PARAM_TYPES(TEEC_VALUE_INPUT, TEEC_VALUE_INPUT,
            TEEC_MEMREF_PARTIAL_INPUT, TEEC_MEMREF_TEMP_OUTPUT);
            op.params[0].value.a           = algo;
            op.params[1].value.a           = mode;
            op.params[2].memref.offset = 0U;
            op.params[2].memref.size      = readSize;
            op.params[2].memref.parent = &input_SharedMemory;
            op.params[3].tmpref.buffer = (void*)output_buf;
            op.params[3].tmpref.size      = readSize;

      res = TEEC_InvokeCommand(&sess, (uint32_t)E_TEEC_CRYS_CMD_AES, &op, &err_origin);
      if (res != (TEEC_Result)TEEC_SUCCESS) {
            (void)printf("TEEC_InvokeCommand failed with code 0x%08x origin 0x%08x¥n", res, err_origin);
      }
}
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
/* Release */
TEEC_ReleaseSharedMemory(&input_SharedMemory);
myFree(output_buf);
```

Manipulating the storage

The following sample source code is the method of operation of the storage.
TEE_OpenPersistentObject failure will generate and store the secret key.

```
/******************************************************************************/
/* Global Variables                                                           */
/******************************************************************************/
static uint8_t        objID[]     = {0x01U,0x02U,0x03U,0x04U};
static uint32_t       objID_len = 4U;

/* Secret key */
static TEE_ObjectHandle secretKey;

/* IV */
static uint8_t      iv[16];
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
TEE_Result TA_CreateEntryPoint(void)
{
    TEE_Result              res;
    uint8_t                 keyData[16];
    TEE_ObjectHandle        object;

    /* Opens a handle on an existing persistent object. */
    res = TEE_OpenPersistentObject((uint32_t)TEE_STORAGE_PRIVATE, objID, objID_len,
        (uint32_t)TEE_DATA_FLAG_ACCESS_READ, &object);
    if (res != (TEE_Result)TEE_SUCCESS) {
        IMSG("###################################First Access###################################¥n");

        /* Random generation of key data. */
        TEE_GenerateRandom((void*)keyData, sizeof(keyData));
        DBUFDUMP(keyData, (int32_t)sizeof(keyData));

        /* Random generation of IV. */
        TEE_GenerateRandom((void*)iv, sizeof(iv));
        DBUFDUMP(iv, (int32_t)sizeof(iv));

        /* Create persistent object. */
        res = TEE_CreatePersistentObject((uint32_t)TEE_STORAGE_PRIVATE, objID, objID_len,
                                (uint32_t)TEE_DATA_FLAG_ACCESS_WRITE,
                                NULL, NULL, 0U, &object);
        if (res != (TEE_Result)TEE_SUCCESS) {
            EMSG("TEE_CreatePersistentObject¥n");
        } else {
            /* Write the key data. */
            res = TEE_WriteObjectData(object, (void*)keyData, sizeof(keyData));
            if (res != (TEE_Result)TEE_SUCCESS) {
                EMSG("TEE_WriteObjectData¥n");
            }
            /* Write the IV. */
            res = TEE_WriteObjectData(object, (void*)iv, sizeof(iv));
            if (res != (TEE_Result)TEE_SUCCESS) {
                EMSG("TEE_WriteObjectData¥n");
            }
            TEE_CloseObject(object);
        }
    } else {
        TEE_CloseObject(object);
    }

    return res;
}
```



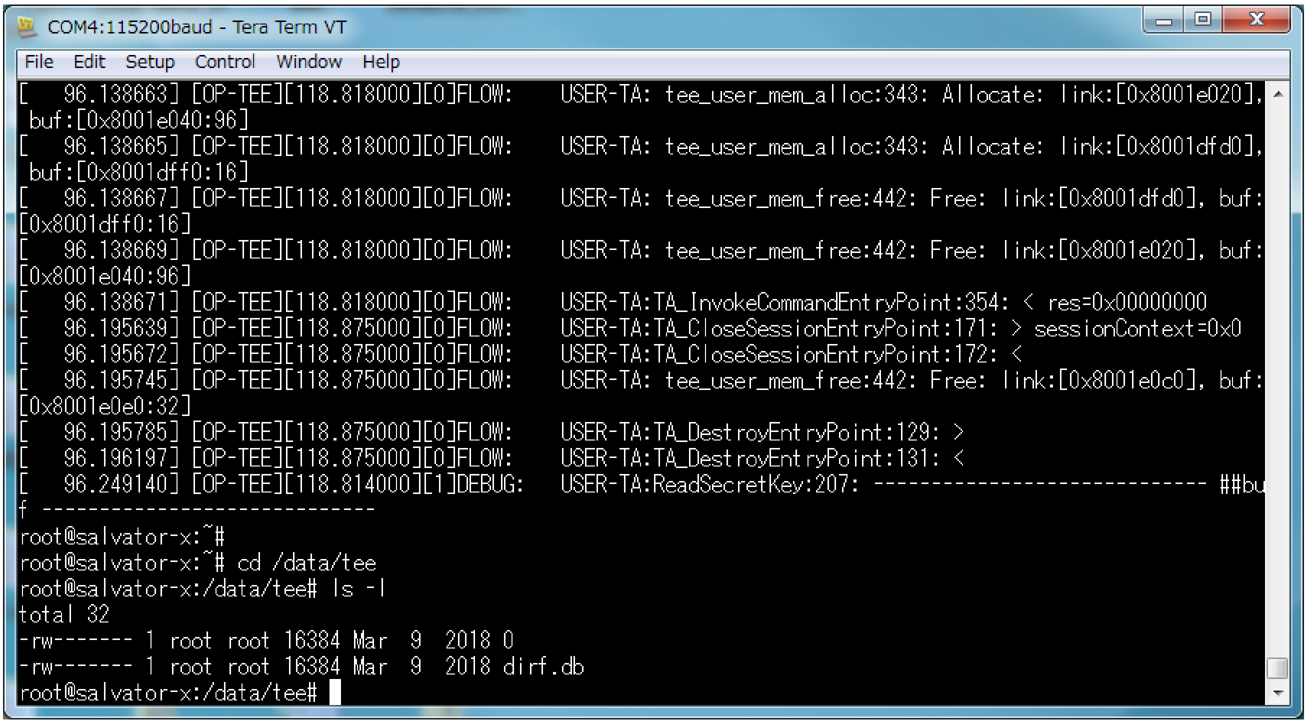
COM4:115200baud - Tera Term VT
File Edit Setup Control Window Help

```
[  OK  ] Started Session c1 of user root.
[  OK  ] Started User Manager for UID 0.

Poky (Yocto Project Reference Distro) 2.1.2 salvator-x ttySC0

salvator-x login: root
Last login: Mon Aug  7 17:04:42 UTC 2017 on tty2
root@salvator-x:~#
root@salvator-x:~#
root@salvator-x:~# /usr/bin/sampleca cbc enc /home/root/a.txt /home/root/b.txt
root@salva
root@salv
total 4
drw------
root@salvator-x:/data/te                         11A47F0002A5D5C51B
root@salvator-x:/data/tee/80                     7F0002A5D5C51B# ls -l
total 4
drw------- 2 root root 4096 Mar  9  20              0304
root@salvator-x:/data/tee/8075A72F0AECE511A        0002A5D5C51B# cd 01020304
root@salvator-x:/data/tee/8075A72F0AECE511A47F0002A5D5C51B/01020304# ls -l
total 8
-rw------- 1 root root  96 Mar  9  2018 block0.0
-rw------- 1 root root 180 Mar  9  2018 meta.1
root@salvator-x:/data/tee/8075A72F0AECE511A47F0002A5D5C51B/
```

#define TA_CRYPTO_UUID { 0x2FA77580U, 0xEC0AU, 0x11E5U, ¥
{ 0xA4U, 0x7FU, 0x00U, 0x02U, 0xA5U, 0xD5U, 0xC5U, 0x1BU} }

objID[] = {0x01U,0x02U,0x03U,0x04U}

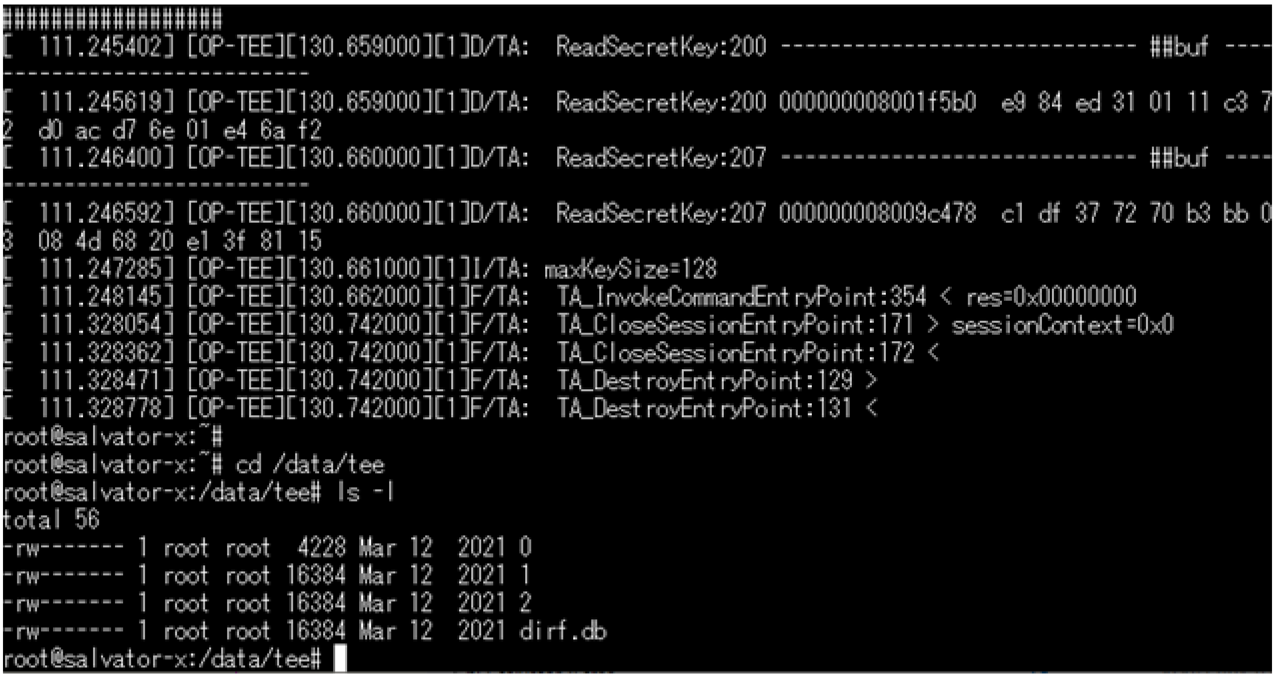
Note) Storage is an example of REE FS (Yocto v2.23.0).
The secret key is created only the first time.



COM4:115200baud - Tera Term VT
File Edit Setup Control Window Help

```
[   96.138663] [OP-TEE][118.818000][0]FLOW:    USER-TA: tee_user_mem_alloc:343: Allocate: link:[0x8001e020],
 buf:[0x8001e040:96]
[   96.138665] [OP-TEE][118.818000][0]FLOW:    USER-TA: tee_user_mem_alloc:343: Allocate: link:[0x8001dfd0],
 buf:[0x8001dff0:16]
[   96.138667] [OP-TEE][118.818000][0]FLOW:    USER-TA: tee_user_mem_free:442: Free: link:[0x8001dfd0], buf:
[0x8001dff0:16]
[   96.138669] [OP-TEE][118.818000][0]FLOW:    USER-TA: tee_user_mem_free:442: Free: link:[0x8001e020], buf:
[0x8001e040:96]
[   96.138671] [OP-TEE][118.818000][0]FLOW:    USER-TA:TA_InvokeCommandEntryPoint:354: < res=0x00000000
[   96.195639] [OP-TEE][118.875000][0]FLOW:    USER-TA:TA_CloseSessionEntryPoint:171: > sessionContext=0x0
[   96.195672] [OP-TEE][118.875000][0]FLOW:    USER-TA:TA_CloseSessionEntryPoint:172: <
[   96.195745] [OP-TEE][118.875000][0]FLOW:    USER-TA: tee_user_mem_free:442: Free: link:[0x8001e0c0], buf:
[0x8001e0e0:32]
[   96.195785] [OP-TEE][118.875000][0]FLOW:    USER-TA:TA_DestroyEntryPoint:129: >
[   96.196197] [OP-TEE][118.875000][0]FLOW:    USER-TA:TA_DestroyEntryPoint:131: <
[   96.249140] [OP-TEE][118.814000][1]DEBUG:   USER-TA:ReadSecretKey:207: ---------------------------- ##bu
f ----------------------------
root@salvator-x:~#
root@salvator-x:~# cd /data/tee
root@salvator-x:/data/tee# ls -l
total 32
-rw------- 1 root root 16384 Mar  9  2018 0
-rw------- 1 root root 16384 Mar  9  2018 dirf.db
root@salvator-x:/data/tee#
```

Note) Storage is an example of REE FS (Yocto v3.6.0).
The secret key is created only the first time.



```
###################
[  111.245402] [OP-TEE][130.659000][1]D/TA:  ReadSecretKey:200 ----------------------------- ##buf ----
-------------------------
[  111.245619] [OP-TEE][130.659000][1]D/TA:  ReadSecretKey:200 000000008001f5b0  e9 84 ed 31 01 11 c3 7
2  d0 ac d7 6e 01 e4 6a f2
[  111.246400] [OP-TEE][130.660000][1]D/TA:  ReadSecretKey:207 ----------------------------- ##buf ----
-------------------------
[  111.246592] [OP-TEE][130.660000][1]D/TA:  ReadSecretKey:207 000000008009c478  c1 df 37 72 70 b3 bb 0
3  08 4d 68 20 e1 3f 81 15
[  111.247285] [OP-TEE][130.661000][1]I/TA: maxKeySize=128
[  111.248145] [OP-TEE][130.662000][1]F/TA:  TA_InvokeCommandEntryPoint:354 < res=0x00000000
[  111.328054] [OP-TEE][130.742000][1]F/TA:  TA_CloseSessionEntryPoint:171 > sessionContext=0x0
[  111.328362] [OP-TEE][130.742000][1]F/TA:  TA_CloseSessionEntryPoint:172 <
[  111.328471] [OP-TEE][130.742000][1]F/TA:  TA_DestroyEntryPoint:129 >
[  111.328778] [OP-TEE][130.742000][1]F/TA:  TA_DestroyEntryPoint:131 <
root@salvator-x:~#
root@salvator-x:~# cd /data/tee
root@salvator-x:/data/tee# ls -l
total 56
-rw------- 1 root root  4228 Mar 12  2021 0
-rw------- 1 root root 16384 Mar 12  2021 1
-rw------- 1 root root 16384 Mar 12  2021 2
-rw------- 1 root root 16384 Mar 12  2021 dirf.db
root@salvator-x:/data/tee#
```

Note) Storage is an example of REE FS (Yocto v5.1.0).
The secret key is created only the first time.

TEE_OpenPersistentObject will succeed next time and thereafter.
Success will create a secret key based on the data read from the storage.

```
/*****************************************************************************/
/* Global Variables                                                          */
/*****************************************************************************/
static uint8_t      objID[]    = {0x01U,0x02U,0x03U,0x04U};
static uint32_t     objID_len = 4U;

/* Secret key */
static TEE_ObjectHandle secretKey;

/* IV */
static uint8_t      iv[16];
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
static TEE_Result ReadSecretKey(void)
{
    TEE_Result          res;
    TEE_Attribute       attrs[1];
    uint8_t             keyData[16];
    uint32_t            readSize;
    TEE_ObjectHandle    object;

    /* Opens a handle on an existing persistent object. */
    res = TEE_OpenPersistentObject((uint32_t)TEE_STORAGE_PRIVATE, objID, objID_len,
        (uint32_t)TEE_DATA_FLAG_ACCESS_READ, &object);
    if (res == (TEE_Result)TEE_SUCCESS) {
        IMSG("###################################Second Access###################################¥n");

        /* Read the key data. */
        res = TEE_ReadObjectData(object, (void*)keyData, sizeof(keyData), &readSize);
        if (res != (TEE_Result)TEE_SUCCESS) {
            EMSG("TEE_ReadObjectData¥n");
        }
        DBUFDUMP(keyData, (int32_t)readSize);

        /* Read the IV. */
        res = TEE_ReadObjectData(object, (void*)iv, sizeof(iv), &readSize);
        if (res != (TEE_Result)TEE_SUCCESS) {
            EMSG("TEE_ReadObjectData¥n");
        }
        DBUFDUMP(iv, (int32_t)readSize);

        /* Create key handle */
        if (res == (TEE_Result)TEE_SUCCESS) {
            TEE_InitRefAttribute(&attrs[0], TEE_ATTR_SECRET_VALUE, (void*)keyData, sizeof(keyData));
            res = TEE_AllocateTransientObject(TEE_TYPE_AES, KEY_SIZE, &secretKey);
            if (res != (TEE_Result)TEE_SUCCESS) {
                EMSG("Error TEE_AllocateTransientObject¥n");
            }
        }
        if (res == (TEE_Result)TEE_SUCCESS) {
            res = TEE_PopulateTransientObject(secretKey, attrs, 1U);
            if (res != (TEE_Result)TEE_SUCCESS) {
                EMSG("Error TEE_PopulateTransientObject¥n");
            }
        }
        TEE_CloseObject(object);
    }

    return res;
}
```

Cryptographic

The following sample source code is an excerpt of encrypt or decrypt.
Please refer to the source for details because the following is an excerpt.

```
/* Secret key */
static TEE_ObjectHandle secretKey;
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
TEE_Result TA_InvokeCommandEntryPoint(void *sessionContext, uint32_t commandID,
            uint32_t paramTypes, TEE_PARAM_ARGV params)
{
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
    /* Reads the secret key */
    res = ReadSecretKey();
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
    /* To encrypt or decrypt the input data with the secret key */
    if (res == (TEE_Result)TEE_SUCCESS) {
        TEE_GetObjectInfo1(secretKey, &info);
        IMSG("maxKeySize=%d¥n", info.maxKeySize);

        res = TEE_AllocateOperation(&op, Algo, Mode, info.maxKeySize);
        if (res != (TEE_Result)TEE_SUCCESS) {
            EMSG("Error TEE_AllocateOperation maxKeySize=%d¥n", info.maxKeySize);
        }
    }
    if (res == (TEE_Result)TEE_SUCCESS) {
        res = TEE_SetOperationKey(op, secretKey);
        if (res != (TEE_Result)TEE_SUCCESS) {
            EMSG("Error TEE_SetOperationKey¥n");
        }
    }
    if (res == (TEE_Result)TEE_SUCCESS) {
        TEE_CipherInit(op, iv, sizeof(iv));
        pos = 0U;
        Remainder = inbuf_size;
        /*
         * TEE_CipherUpdate since the update process is called in TEE_CipherDoFinal is not required.
         * The following comment out is an example when carry out TEE_CipherUpdate.
         * Big data can not send at one time to Secure World from Normal World.
         * If this is the case, you will need to implement separately in TEE_CipherUpdate and TEE_CipherDoFinal.
         */
        //while ((Remainder % BLOCK_SIZE) == 0U) {
        //    res = TEE_CipherUpdate(op, &inbuf[pos], BLOCK_SIZE, &outbuf[pos], &outbuf_size);
        //    if (res != (TEE_Result)TEE_SUCCESS) {
        //        EMSG("Error TEE_CipherUpdate¥n");
        //        break;
        //    }
        //    pos += BLOCK_SIZE;
        //    Remainder -= BLOCK_SIZE;
        //
        //    /* Exit to leave the last of the block */
        //    if (Remainder == BLOCK_SIZE) {
        //        break;
        //    }
        //}
        /* Last block */
        if (res == (TEE_Result)TEE_SUCCESS) {
            res = TEE_CipherDoFinal(op, &inbuf[pos], Remainder, &outbuf[pos], &outbuf_size);
            if (res != (TEE_Result)TEE_SUCCESS) {
                EMSG("Error TEE_CipherDoFinal¥n");
            }
        }
    }
    /* Free OperationHandle */
    if (op != TEE_HANDLE_NULL) {
        TEE_FreeOperation(op);
    }
    OUTMSG("res=0x%08x¥n", res);
    return res;
}
```

Revision History	Sample Dynamic TA Application Note

Rev.	Date	Description	
		Page	Summary
1.0.0	Apr. 15, 2016	—	First Edition issued.
1.0.1	Aug. 24, 2016	1	Version of a reference Security BSP User's Manual has been updated.
1.0.2	Dec. 22, 2016	9	Add a description of input data.
1.0.3	Feb. 15, 2017	1	Version of a reference Security BSP User's Manual has been updated.
1.0.4	Jul. 12, 2017	—	Fixed the format of the document (trademark, etc.)
1.0.5	Mar. 14, 2018	—	Fixed the format of the document (trademark, etc.)
		3	Add M3N and E3 board.
		11	Fixed the code in the appendix.
		14	Add REE FS output image of Yocto v2.23.0 and Yocto v3.6.0.
2.0.0	Nov. 5, 2018	—	Fixed the format of the document(Address List.)
		3	Add Ebisu-4D board.
3.0.2	Apr. 6, 2021	2	Changed ARM notation to Arm.
		3	Add D3 board.
		5	Changed the software name from ARM Trusted Firmware to Trusted Firmware-A.
		15	Add REE FS output image of Yocto v5.1.0.
3.0.3	Aug. 16, 2021	—	Fixed the format of the document (Notice, Address List.)
		—	Add information of Gen3e.

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Sample Dynamic TA
Application Note: Software

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