Trusted Firmware – M RPC Test Framework

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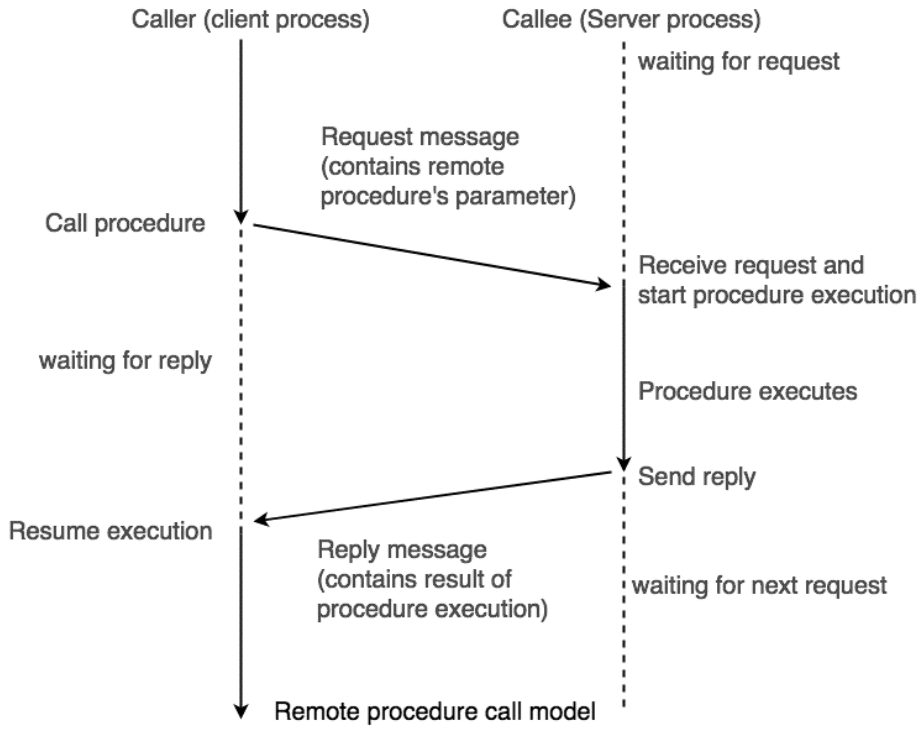
What is RPC?

*https://en.wikipedia.org/wiki/Remote_procedure_call
**https://www.geeksforgeeks.org/remote-procedure-call-rpc-in-operating-system/

- Remote procedure call (RPC)*
  - procedure calls executed in a different address space.
  - usually in a form of client/server interaction to invoke calls.
  - can be between any two entities with different processes and have different address space.
- Example**,



Why RPC style tests in TF-M?

- Current test framework is built as part of NS binary.
  - Inflexible, as tests increases, the memory requirement increases.
  - because of low footprint platform boards, we must run different binaries running subset of tests at a time.
    - e.g. some Musca boards can't afford the whole PSA ACK test suite in one go.
- Running more complex test frameworks targeted to PSA APIs is not feasible due to the limitation of the environment where the test runs.
  - e.g. mbed TLS based PSA regression
- Current test output is provided as text logs along the UART channel.
  - making it difficult to parse on the host system to understand failure.

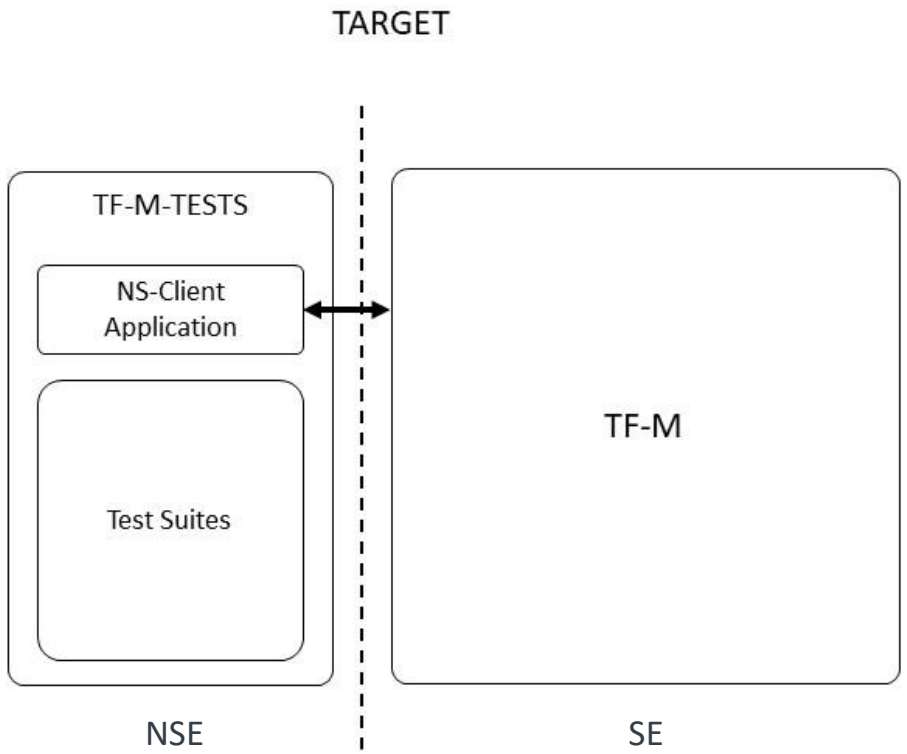
Why RPC style tests in TF-M?

- Therefore, we require a solution which can interrogate with the board programmatically.
- RPC tests makes it easier to scale test cases.
  - since the entire test framework can run within host.
  - The size of the framework of the tests running on the NS world remains constant over time.
  - Could help in enabling all the features and tests on target by default.
- This allows to have rich test environments and increases flexibility and add more options for automation integration.
  - making it easier to understand failures.

- Cons:
  - This solution makes it more difficult to simulate threads on the NS environment.
    - although the NS tests should focus on API validity rather than verifying more of the NS-ID identification capability of TF-M.

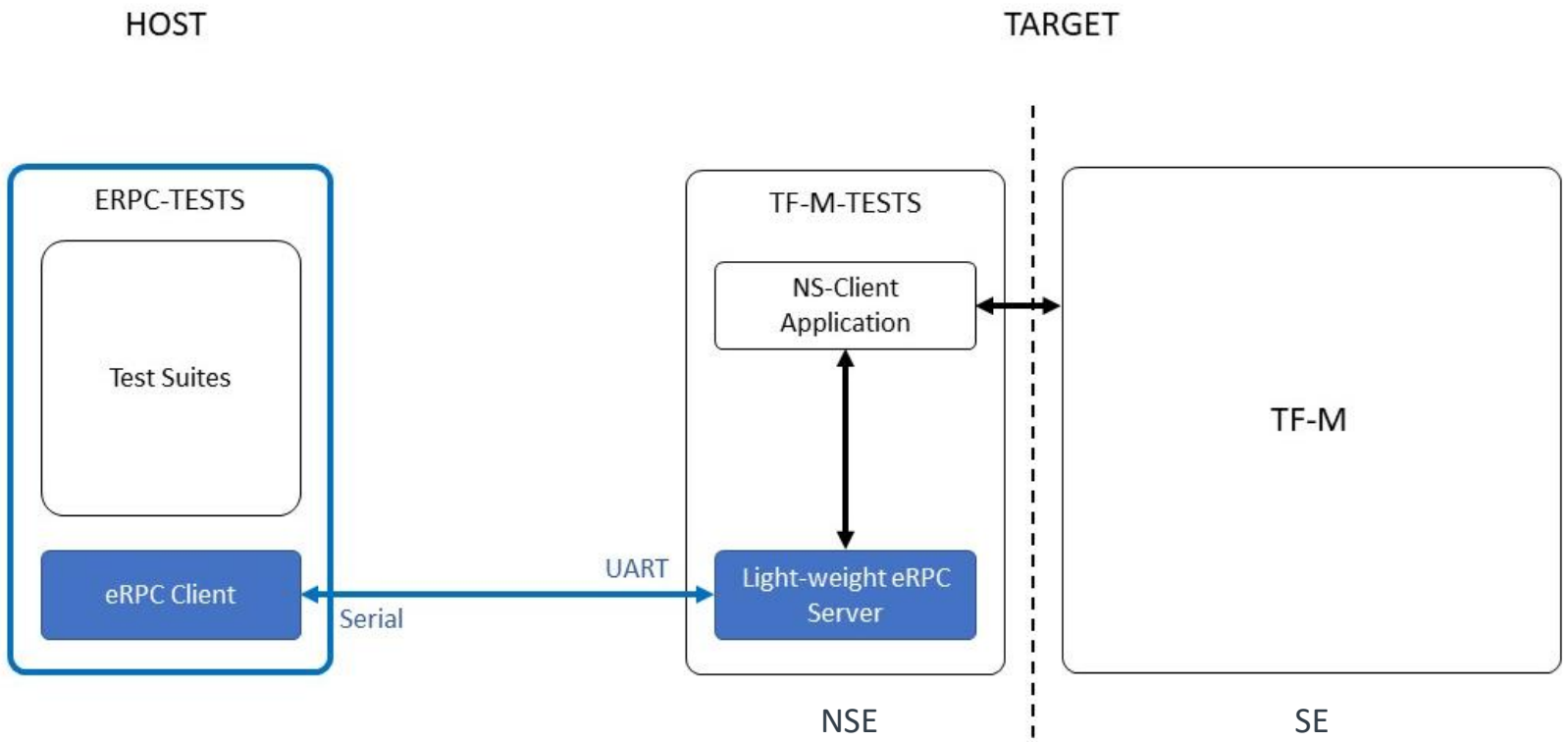
Proposed Framework

- Our current framework looks like,



Proposed Framework

- New proposed test framework



Proposed Framework

- In the proposed test framework,
  - On the target,
    - There is a ns client application running RPC test framework.
    - Includes a lightweight server handler which receives and handles service calls.
    - Server session runs indefinitely(Until requested to stop)
  - On the host,
    - Contains all testsuites without target limitations.
    - Has RPC client making service request and receiving processed data.
    - Tests can be built seperately to the target binaries.
    - Can run multiple times for long as server session is active.
  - The communication is done over Serial-UART channel.

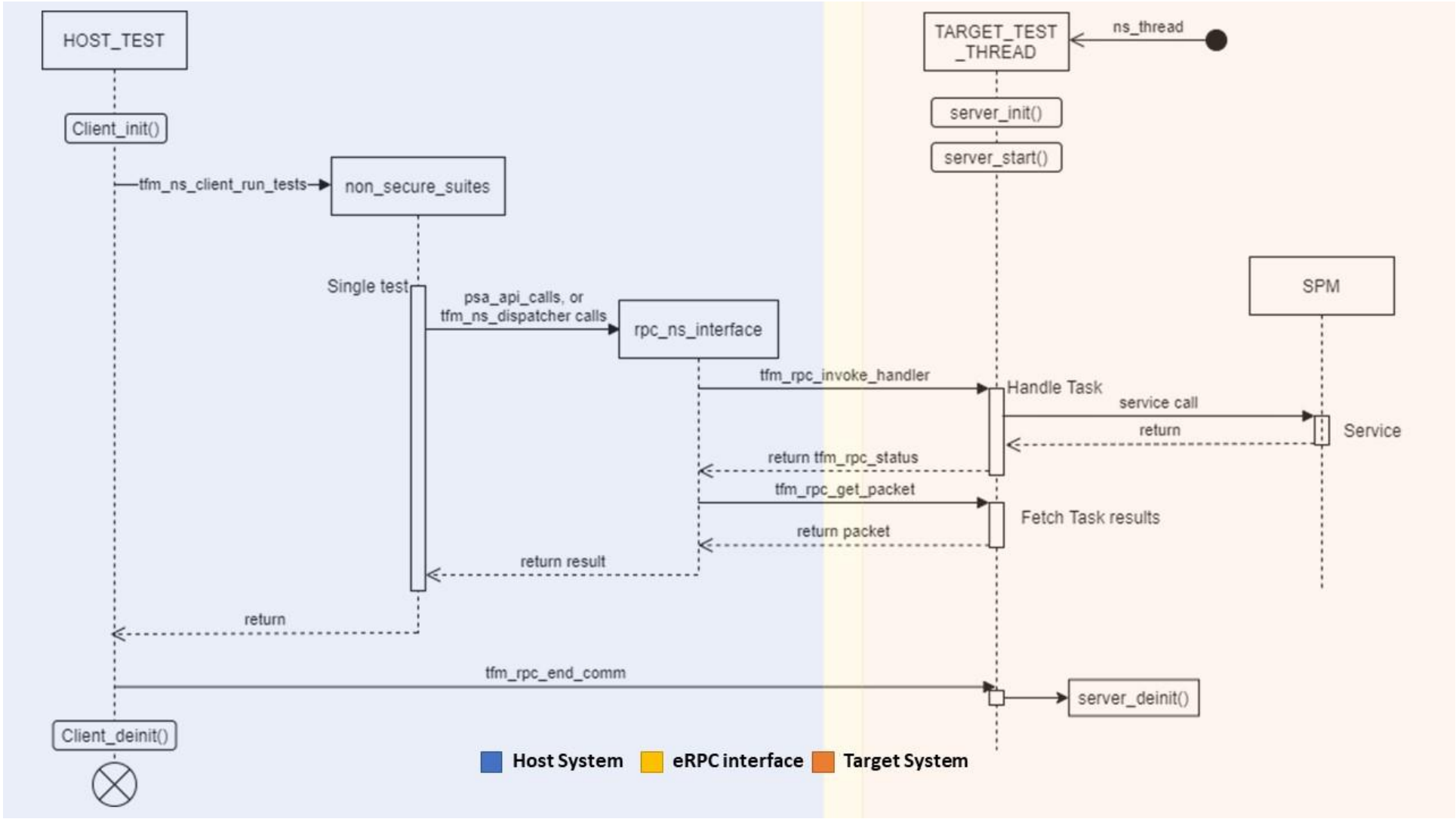
RPC interface

- In this work, we have used eRPC* framework for the RPC interface
  - Lightweight
  - Easy to integrate for our use case.
    - supports abstraction over CMSIS-UART drivers which we use in our platforms
  - Helps with serializing and de-serializing data into byte-streams
  - Transports them via common communication channels(serial-UART for our use case)
  - At each end this data is interpreted into a function call and corresponding arguments

  - Memory footprints is very low.
  - Licensing: Unrestrictive BSD 3-clause

**https://github.com/EmbeddedRPC/erpc*

Proposed Software Model



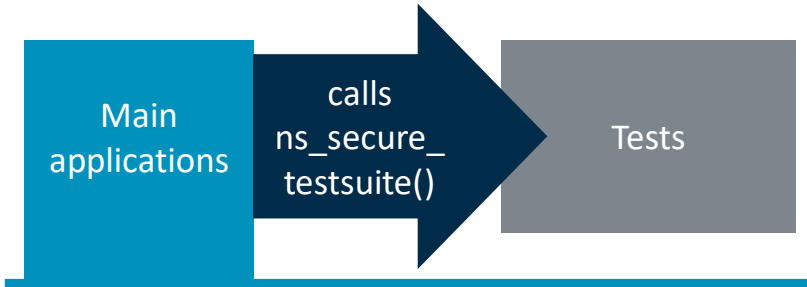
Proposed Software Model

Host Program

Main applications

Proposed Software Model

Host Program



- Main host side program.
- Handles client rpc init and deinit.
- Calls tests/secure_fw/non_secure_suites.c

Proposed Software Model

Host Program

- The prototype of the testsuite functions are same.
  - Based on IPC or Library mode, the corresponding interface is used.

Proposed Software Model

Host Program

- The incoming service calls are handled by shim functions.
  - Every TF-M service api has an id which is used to identify the function or the type of interface call used.
- It calls rpc_host_handler to package these data along with invec-outvec parameters.

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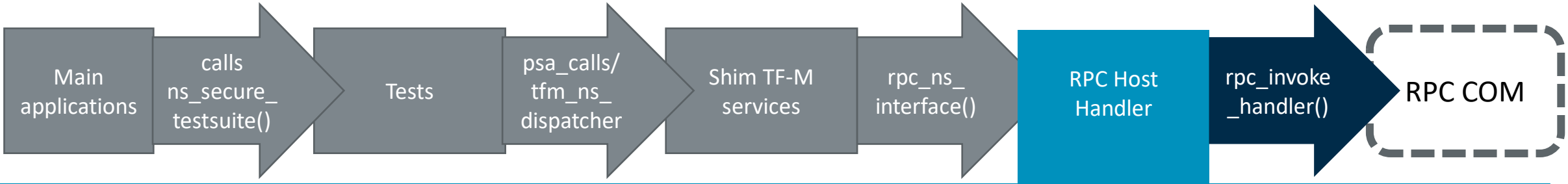
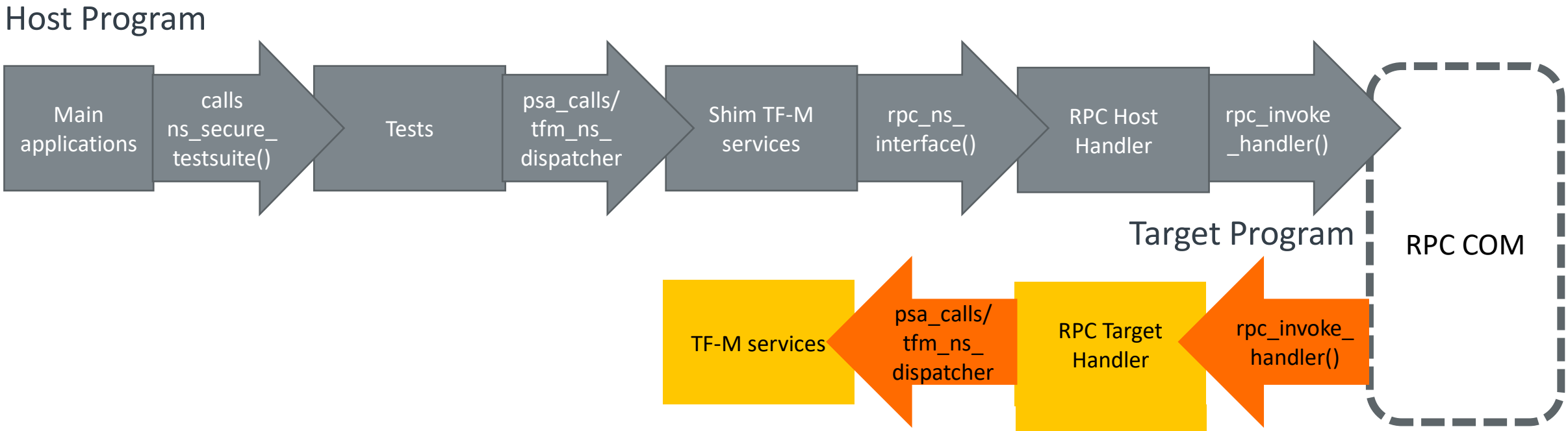
Proposed Software Model

Host Program



- Packages parameters(invecs, outvecs) and properties of the call, and other data into *rpc packet.*
- This package is sent to eRPC to transmit to the target.

Proposed Software Model



- Receives eRPC data.
- Un-packages invecs, outvecs, types of call, and other data from *rpc package.*
- Based on the type of call, TF-M services are called.

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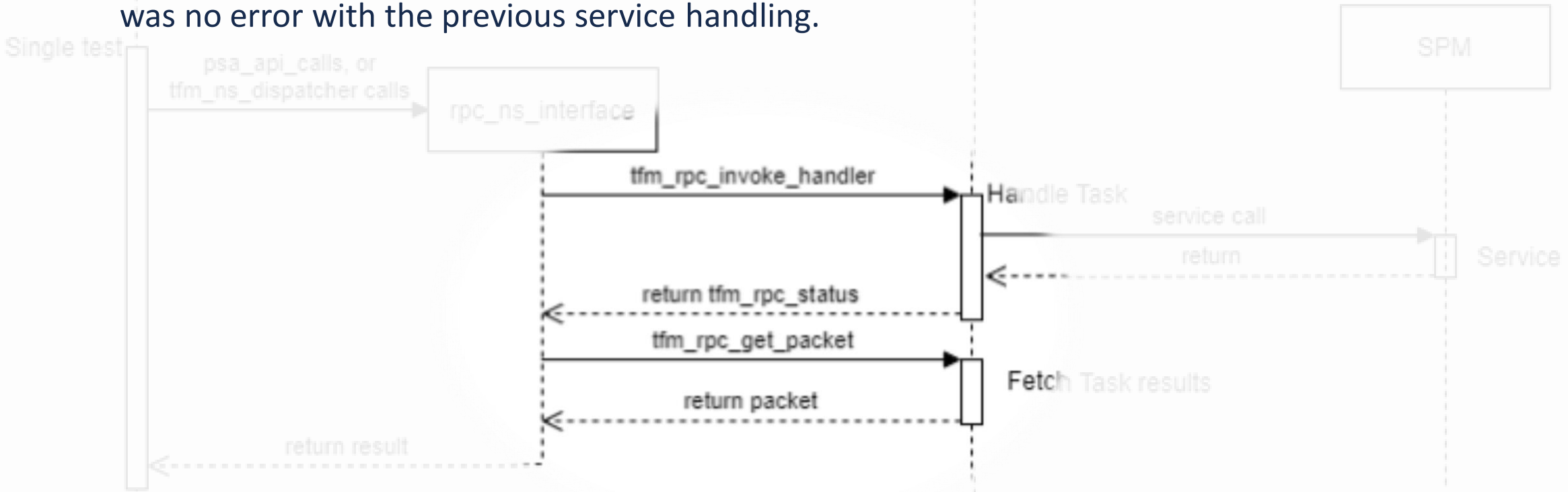
Proposed Software Model

- *'RPC Sequence*' in this work is defined as a set of,
  - *tfm_rpc_invoke_handler* handles tfm services and calls and returns the status of this event. A tfm_rpc_packet is sent to the server which includes all the data necessary to handle a remote tfm service call.
  - *tfm_rpc_get_packet* fetches the data after a handler invocation. The processed data is sent if there was no error with the previous service handling.



Executing tests

- We have evaluated the framework by running tests for TEST_NS_ATTESTATION, TEST_NS_AUDIT, TEST_NS_CRYPTO, TEST_NS_ITS, TEST_NS_PS*, TEST_NS_PLATFORM.
  - They run and pass as expected.
- We can build the binaries by setting the macro “-DTEST_RPC_API=ON” on our existing buildsystem.
  - Currently, host is Linux system.
- Execute following command to run the host program,

<cmake_build folder>/host_rpc/tfm_rpc_host -p <target portname> -e

**To get around the limitation of multiple threads for the Protected Storage test suites, we have stubbed those functions since we don’t need them currently.*

Resulting Memory Footprint

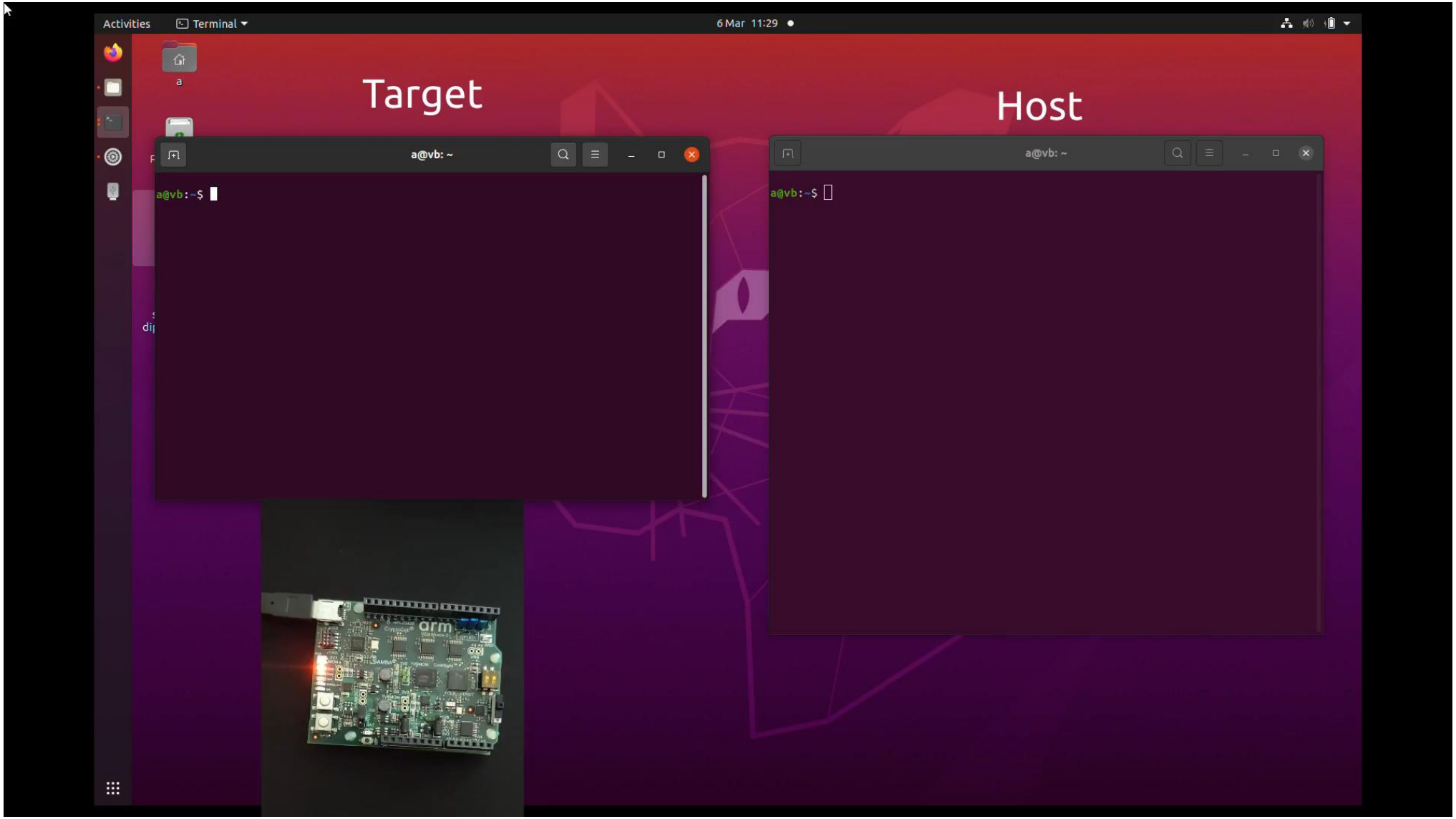
- The memory footprint of target(for tfm_ns binary) is given as follows,

	Lib Model (in B)		**IPC Model** (in B)	
	FLASH	**RAM**	**FLASH**	**RAM**
No Tests	14088	13984	14088	13984
With NS Tests	129116	25152	131440	25184
With RPC_NS tests*	22280	14240	22180	14240

- The advantage of this framework is that RPC_NS test figure is going to stay the same irrespective to the complexity and the number of test cases on the host-side.

**Enabled* TEST_NS_ATTESTATION, TEST_NS_AUDIT, TEST_NS_CRYPTO, TEST_NS_ITS, TEST_NS_PS, TEST_NS_PLATFORM.

Demo 1



Usecase: Python Wrapper prototype

- Using RPC framework, we can interrogate with the board in real-time.
  - Helps understanding failures easily.
- To evaluate this functionality we have used CFFI as our backend to link with rpc_host shared library.
  - Easy to integrate for our current use.
  - No additional learning of wrapper languages or maintenance.
  - Compatible with Python 2 and 3.

Usecase: Python Wrapper prototype

- Preparing host client using following code.

```
from tfmrpc import crypto, rpc

_rpc = rpc.rpc('tfmrpc/wrapper_defs/rpc.h', './libtfm_rpc_host.so’)
_crypto = crypto.crypto('tfmrpc/wrapper_defs/crypto.h', './libtfm_rpc_host.so’)

 portname = _rpc.new('char[]', '/dev/ttyACM0')
 _rpc.tfm_rpc_host_init(portname)
```

Usecase: Python Wrapper prototype

- Defining variables

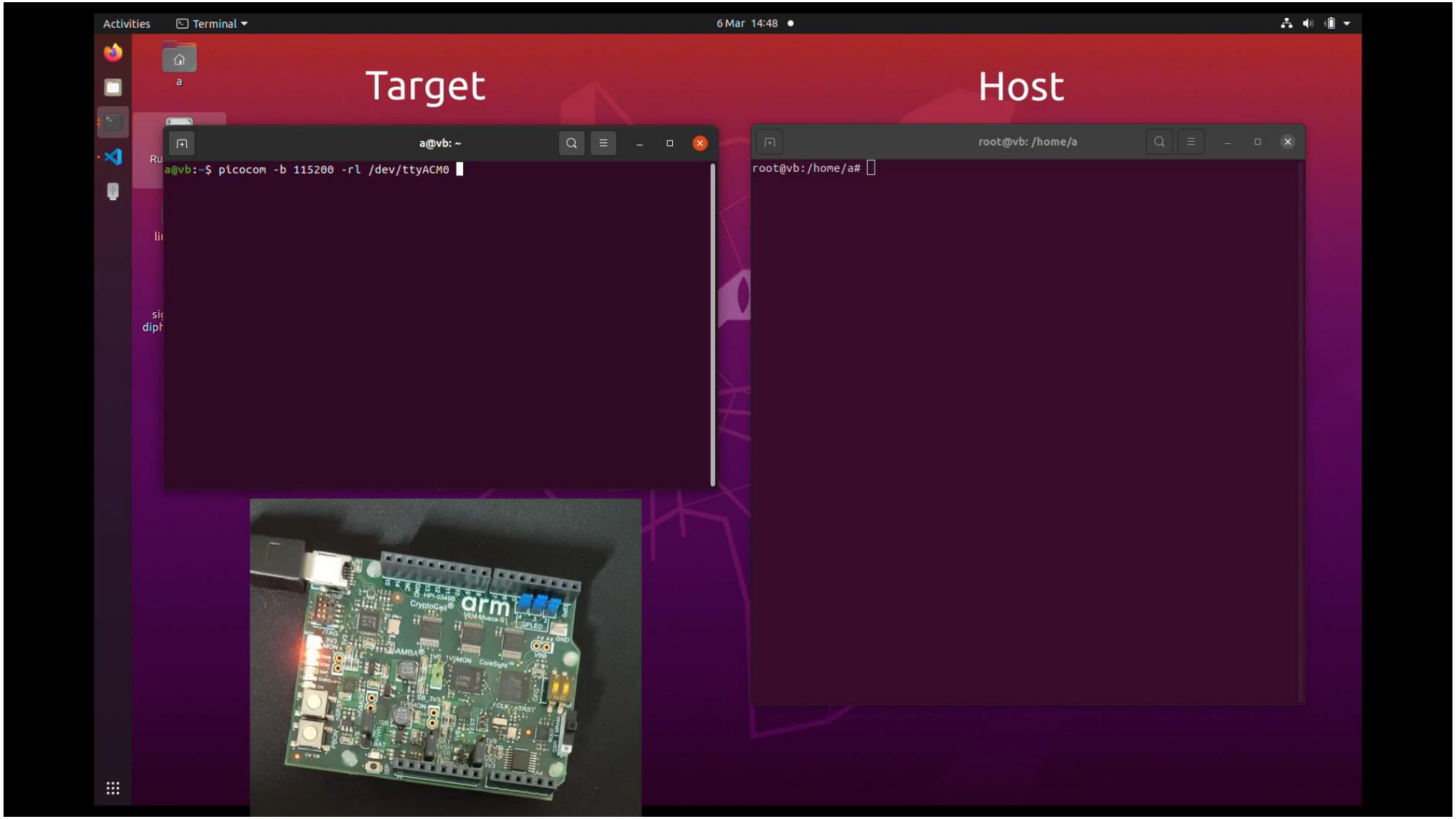
```
_attr = _crypto.psa_key_attributes_t.new(   \
                            _type = 9216,   \
                            _bits = 0,      \
                            _lifetime = 0,  \
                            _id = 0,        \
                            _usage = 1,     \
                            _alg = 0)

_data = _crypto.new('char[]', 'This is py_wrapper test')
_data_length = 24
_key = _crypto.new('psa_key_id_t *')
```

- An example to call a tf-m service from host is given below:

```
_crypto.psa_import_key(_attr, _data, _data_length, _key)
```

Demo 2



References

- https://github.com/EmbeddedRPC/erpc/wiki
- https://embeddedrpc.github.io/
- https://cffi.readthedocs.io/

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Thank You
Danke
Gracias
Grazie
谢谢
ありがとう
Asante
Merci
감사합니다
धन्यवाद
Kiitos
شكرًا
ধন্যবাদ
תודה