Engineering Cryptographic Software

The Software assignment

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Winter 2021

Background

Writing crypto software

1. Start with slow, potentially insecure, but functioning reference implementation in C
2. Remove main sources for timing leakage, i.e.,
    - remove secret-dependent branches
    - remove secretly indexed memory access
3. Profile the code, optimize most important routines
4. Typically use assembly for (micro-)architecture specific optimization

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Typical minimal building blocks

1. Elliptic-curve Diffie-Hellman (ECDH) for key exchange
2. Some streamcipher for bulk data encryption
3. Some symmetric authenticator (MAC)

The assignment

- Given C reference implementations of
  - ChaCha20 stream cipher,
  - Poly1305 authenticator, and
  - ECDH on Curve25519 in Edwards form,
- produce optimized implementations for the ARM Cortex-M4

For details see `ecsw2021-assignment.pdf` in Brightspace or at https://cryptojedi.org/peter/teaching/ecsw2021/ecsw2021-assignment.pdf

Getting started: Target platform

STM32F407

- ARM Cortex-M4
- 32-bit architecture
- 192 KiB RAM
- 1 MiB Flash
- 168 MHz
- 24 MHz for benchmarking

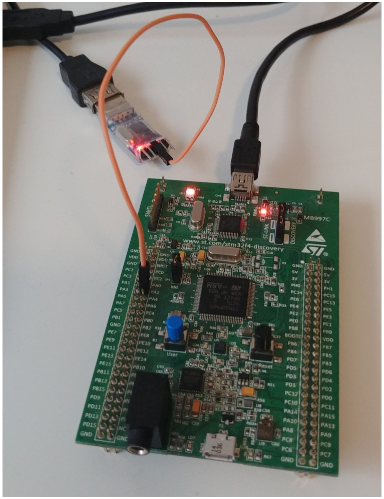
Getting started: Setting up toolchain

- **Option 1:** Using virtual machine image (recommended)
  - Ubuntu 18.04
  - Everything you need pre-installed
  - First steps in the next slides
- **Option 2:** Install toolchain on your own Linux
  - Tutorial: `https://github.com/joostrijneveld/STM32-getting-started`
  - Depending on your OS, we might not be able to help you

Getting started: Setting up toolchain

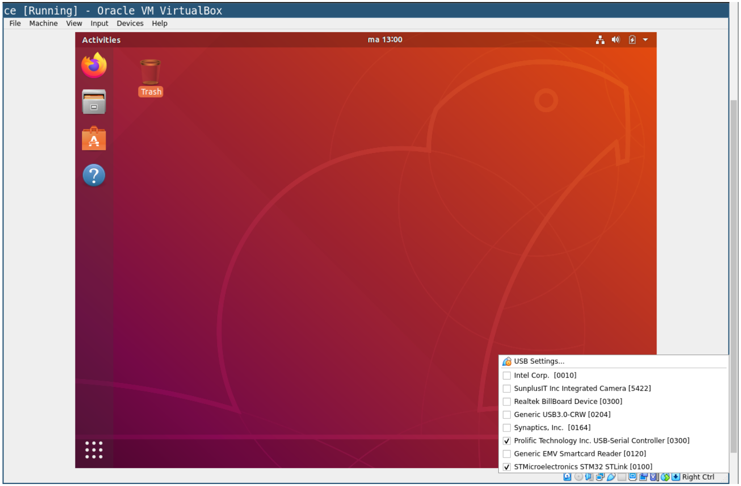
- Install Virtualbox: https://www.virtualbox.org/
- Download and import image:
  http://sandor.cs.ru.nl/ce2021.ova
- Start VM and login with
  Username: `ce`
  Password: `ce`
- `/home/ce/ce2021-sw-assignment/` contains the assignment

Getting started: Connecting discovery board



- Connect USB cable to your machine
  - Used for flashing and as power supply
- Connect `PA2` pin with `RXD` pin of UART-USB connector
  - Used for receiving serial output
  - You may also connect `GND` with `GND`

Getting started: Mapping USB devices to VM


ce [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Activities
ma 13:00
Trash
Right Ctrl

USB Settings...

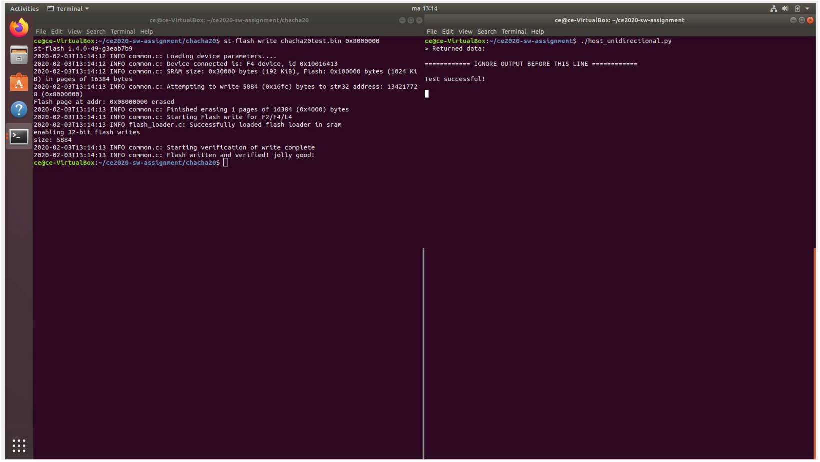
- [ ] Intel Corp. [0010]
- [ ] SunplusIT Inc Integrated Camera [5422]
- [ ] Realtek BillBoard Device [0300]
- [ ] Generic USB3.0-CRW [0204]
- [ ] Synaptics, Inc. [0164]
- [✓] Prolific Technology Inc. USB-Serial Controller [0300]
- [ ] Generic EMV Smartcard Reader [0120]
- [✓] STMicroelectronics STM32 STLink [0100]

- Map board and UART-USB connector into the virtual machine

Getting started: Flashing software and receiving output

- Compile libopencm3 library
```
cd ~/ce2021-sw-assignment/libopencm3
make
```
- Compile binary (e.g., test for chacha20)
```
cd ~/ce2021-sw-assignment/chacha20
make
```
- Flash binary to the board
```
st-flash write chacha20test.bin 0x8000000
```
- Receive output
```
cd ~/ce2021-sw-assignment/
./host_unidirectional.py
```

Getting started: Flashing software and receiving output


Activities
Terminal
ma 13:14
ce@ce-VirtualBox: ~/ce2020-sw-assignment/chacha20
File Edit View Search Terminal Help
ce@ce-VirtualBox: ~/ce2020-sw-assignment
File Edit View Search Terminal Help

```
ce@ce-VirtualBox:~/ce2020-sw-assignment/chacha20$ st-flash write chacha20test.bin 0x8000000
st-flash 1.4.0-49-g3eab7b9
2020-02-03T13:14:12 INFO common.c: Loading device parameters....
2020-02-03T13:14:12 INFO common.c: Device connected is: F4 device, id 0x10016413
2020-02-03T13:14:12 INFO common.c: SRAM size: 0x30000 bytes (192 KiB), Flash: 0x100000 bytes (1024 Ki
B) in pages of 16384 bytes
2020-02-03T13:14:13 INFO common.c: Attempting to write 5884 (0x16fc) bytes to stm32 address: 13421772
8 (0x8000000)
Flash page at addr: 0x08000000 erased
2020-02-03T13:14:13 INFO common.c: Finished erasing 1 pages of 16384 (0x4000) bytes
2020-02-03T13:14:13 INFO common.c: Starting Flash write for F2/F4/L4
2020-02-03T13:14:13 INFO flash_loader.c: Successfully loaded flash loader in sram
enabling 32-bit flash writes
size: 5884
2020-02-03T13:14:13 INFO common.c: Starting verification of write complete
2020-02-03T13:14:13 INFO common.c: Flash written and verified! jolly good!
ce@ce-VirtualBox:~/ce2020-sw-assignment/chacha20$
```

```
ce@ce-VirtualBox:~/ce2020-sw-assignment$ ./host_unidirectional.py
> Returned data:

============ IGNORE OUTPUT BEFORE THIS LINE ============

Test successful!
```