GSoC 2020 Final Report

apertus° Association

AXIOM Remote: Bootloader improvement and extension

Priya Pandya

Mentor: Andrej Balyschew

Co-mentor: Herbert Poetzl

August 31, 2020

Contents

1 Introduction

As the title says, my work is to improve the functionality of the existing bootloader and add more features to it. The task is described here The main feature to be implemented was **flashing of PIC16 firmware using PIC32 bootloader** and some other features:

- PIC32 self-programming
- Communication between bootloader and firmware
- Power saving modes for PIC32

2 Work Product

All the code produced by me during GSoC 2020 can be found in this repository branch.

3 Tasks Implemented

3.1 Phase I

The following tasks were implemented in the first phase, along with detailed understanding and reading up about the project:

3.1.1 Host PC script

The main script, which is written in Python, runs on the host PC has all the functionalities to select the chip, the mode (read or write), the HEX file to be flashed etc.
The command-line options/arguments are:

- **port** : path to the USB port
- **hex** : path to the HEX file to flash
- **chip** : to select the microcontroller chip, it has three options: km_west, km_east, pic32
- **version** : display the versions of the firmware
- **read** : to read code back from the PIC memory
- **write** : write the HEX code in the PIC memory

The examples to run the python script are:

Reads code from Key Manager west

```
python3 Remote_UART_Programmer.py --read --chip km_west --port /dev/
    ttyACM0
```

Writes code to the Key Manager west

```
python3 Remote_UART_Programmer.py --write --chip km_west --port /dev/
    ttyACM0 --hex /path/to/hex
```

In the script, the HEX file is processed using the **intelhex** Python library The reading and writing to and from the USB port is done using **pyserial**. To communicate with the bootloader, an ASCII communication protocol is used which has some commands which are sent over to the bootloader and it sends back acknowledgement (negative and positive both).

3.1.2 Command Packet

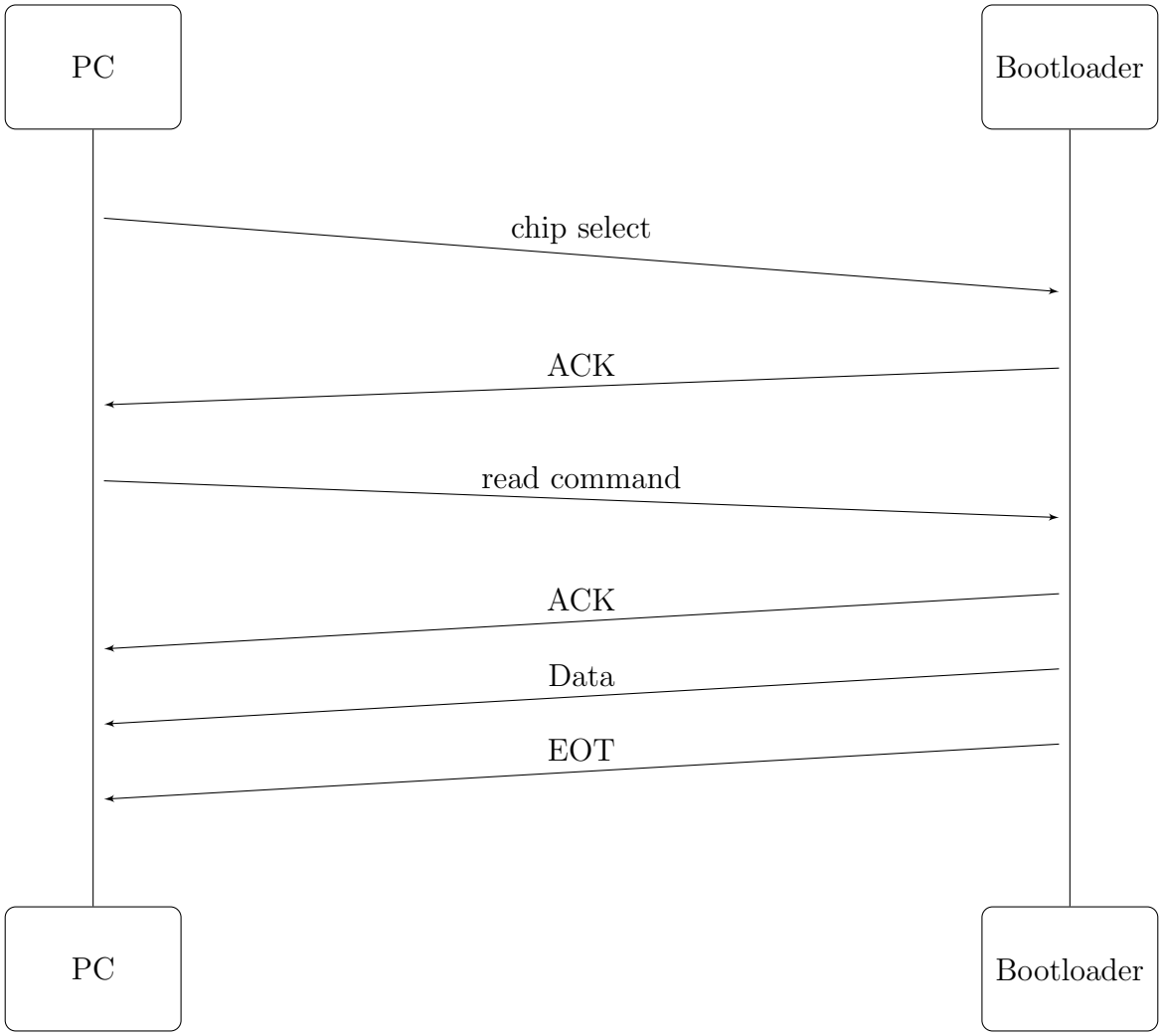
This is sent to the remote from the PC using the Python script. It has the following structure:

<request type><sequence number><CRC8><RS><fields><EOT>

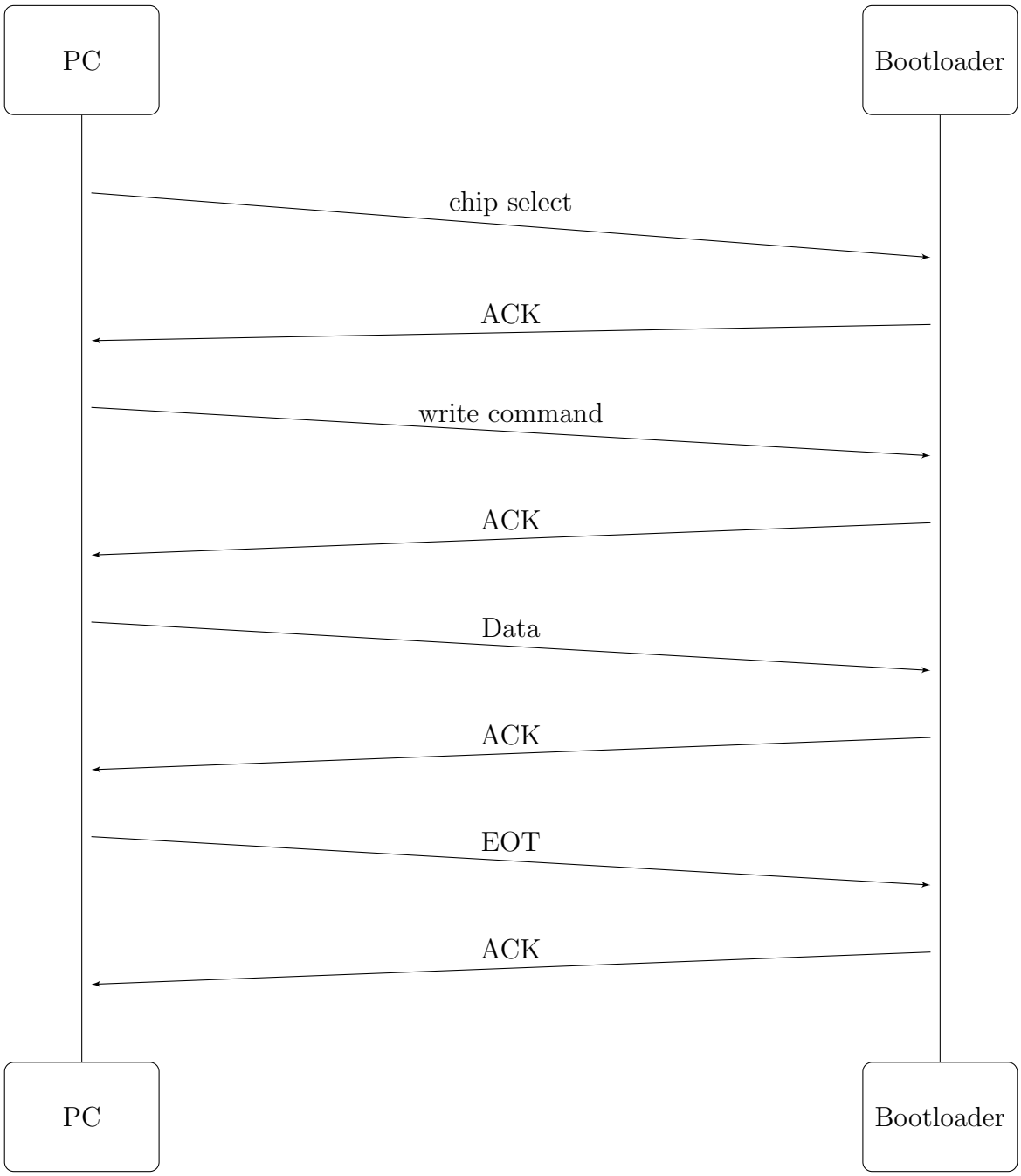
- <**request type**> : It can have values G (get), S (set) or R (return value).
- <**sequence number**> : It is a number starting from 0 and increasing, it is present to check the validity of the packet.
- <**CRC8**> : It is the CRC8 (checksum) calculated of everything which comes after it.
- <**RS**> : This is the record separator which has the value 0x1e in hex and it's inserted between the field values.
- <**fields**> : This contains the chip name or the mode (read or write).
- <**EOT**> : It means the end of transmission and has value 0x04 in hex.

The following images demonstrate a simple read and write process between the host PC and the remote:

READ DATA



WRITE DATA


PC
Bootloader
chip select
ACK
write command
ACK
Data
ACK
EOT
ACK
PC
Bootloader

3.1.3 ProcessCommand()

The class USBCDCDevice already had the methods to read and send the data from the bootloader to the PC via the USB port connection. I've added a function ProcessCommand() in the main.cpp of the firmware which receives the command string from the PC and checks it and accordingly decides whether to send ACK or NACK.

3.1.4 Callback method

The processing of the packet received from the host can't be done in the USBCDCDevice class as it can clutter up the code there so an additional callback function is implemented. The processing of the received data is moved to the other class and also to customize the different methods of the processing. This callback function is called by the ProcessCommand() in the main.cpp.

3.2 Phase II

The progress for this phase was as follows:

- The connection between the host PC and the remote is successfully established.
- Some changes are made to the Python script developed in the Phase-I, now the Set/Get command, every sequence number digits, checksum part, ⟨RS⟩, ⟨EOT⟩ and every character of fields take 1 byte each. The reason I did this is because if we consider ⟨EOT⟩ value as "0x4" then it's length will be 3 which takes up too much space and iteration will increase in the ProcessCommand() so instead of that I'll take it's ASCII character so it'll only take 1 byte space.

  To explain this better, here is an example to know the difference between the previous command string and the current one:

  Previous: "S0014d0x1epic320x4", it takes 18 bytes space

  Current: "S1M[RS]pic32[EOT]", it takes 10 bytes space
- The ProcessCommand() method on the remote side is now broken-up into many subroutines so as to ease the process and declutter the code.

3.3 Phase III

In the last phase much progress was done:

3.3.1 GetInfo()

This method is added in the main.cpp. Its function is to extract the useful information from the packet received from the host PC then check the sequence number and CRC8 and send an ackknowledgement. This also calls another method **SelectChip()**.

3.3.2 CRC8 class and sequence nunber

The package is received in the ProcessCommand() and then the fields part is extracted in the GetInfo() and then using this class the CRC8 is calculated. To send a positive acknowledgement to the host PC, both the sequence number and the checksum need to be the same as the sequence number and the CRC8 present in the packet. This validation was successfully done in this phase.

3.3.3 SelectChip()

This takes the chip name as the argument and then uses the ICSProgrammer class to activate that respecive chip. It calls the **GetKMData()** or **WriteData()** method depending upon the operation (read or write).

3.3.4 GetKMData() and WriteData()

These use the ICSProgrammer methods (EnterLVP(), SendCommand(), ExitLVP() etc.) to read or write the data from or to the selected chip.

4 Challenges Faced

4.0.1 Phase I

The main problem which I initially faced was to properly understand the flashing process in which Andrej helped a lot by using various examples. I also realised that while writing the proposal I had underestimated this task. Although it may seem simple that all I need to do is to put a HEX file into the micro controller's memory but the real challenge is to make the process as user-friendly as possible.

One of the other obstacles I encountered when I wanted to do some tests for the section 2.2 code. The bootloader HEX file had some problems and was flashing but not creating the

USB port so communicating it with the host PC was not possible. So Andrej told to do the testing on the firmware HEX for now as that worked perfectly and I was also able to do the tests.

4.0.2 Phase II

While trying to send the command string from the host PC to the remote, I discovered that the string of length greater than 8 is not received at the remote's end and the script usually freezes. After debugging with Bertl and BAndiT we concluded that there is some bug either in the USB code or hardware issue. So the packet is cropped and then sent to the remote.

4.0.3 Phase III

- CRC8 on the host side (the Python script) was giving some trouble when converting to 1 byte length due to which the reading of data was not becoming possible, so I had to do changes to that data byte.
- The intelhex gives data in decimal (int data type) so when sending that data, the length of each data was coming out to be between 1 to 5 bytes so had to make many changes to lower the length of that data which took a lot of time, so now the data is ready on the host side and receiving part is also ready on the remote side.

5 Conclusion

The flashing task is taking time as it may sound simple but the implementation part is quite complex with numerous big and small obstacles. Especially, the integration of the hardware and the software was a little time taking in the beginning. Some of the tasks mentioned in my proposals are still left which I'll be working on after the GSoC period.

My overall experience with apertus° Association was great. I learnt everything from coding styles, microcontrollers, various Python manipulations and modules to those low-level parts of C++ which I had never explored. My mentor (Andrej) was very supportive and was always available whenever I was stuck anywhere or could not understand a portion.