

WiBo - The Wireless Bootloader

REVISION HISTORY

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Abstract

The following article describes the usage of the uracoli wireless bootloader. WiBo works like a regular bootloader, except that it uses the radio transceiver instead of a UART. WiBo modifies the flash directly, therefore no special backup flash memory, like in other over the air upgrade (OTA) solutions, is required on the transceiver board.

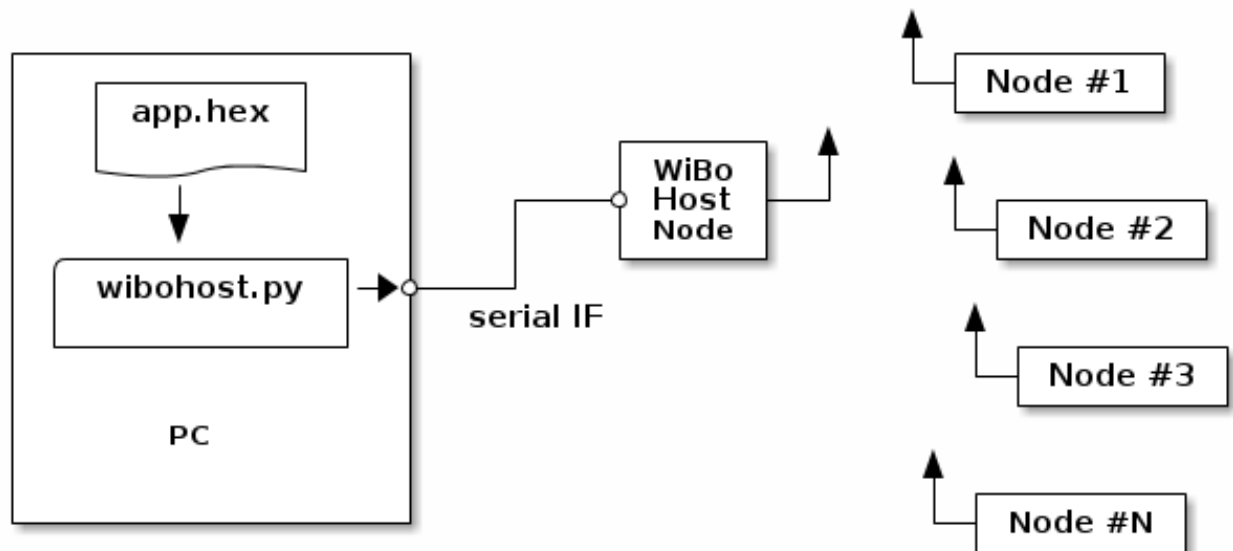
1 Concept

The WiBo framework provides a method to program the MCU that controls the transceiver. Three components are involved,

- a PC with USB or serial interface, running the script `wibohost.py`,
- a host node, running with the `wibohost` firmware and
- the network nodes that have the bootloader installed.

The python script `wibohost.py` sends a hexfile `app.hex` in slices to the host node. It transmits these data slices as unicast or broadcast frames to the network nodes. The network nodes collect the data slices and program them with SPM (self programming mode) commands in the flash application section of the microcontroller.

In order to verify if a node was programmed correctly, the host and network nodes calculate a CRC16 during the transmission and reception of the data slices. When programming is completed, the `wibohost` can query the CRC from the nodes and compare with its own checksum.



The bootloading can be done either in **unicast** mode or in **broadcast** mode. In unicast mode one node is programmed with program image at one time. In broadcast mode, multiple nodes receive the image at the same time. This is useful for programming multiple instances of identical hardware with a single firmware image.

The host site consists of a **Python** script and the host node that runs the `wibohost` firmware. The script `wibohost.py` uses the module `pyserial` for serial communication with the host node. It reads and parses the given hex file and transfers it in slices to the host node. The host node firmware sends this slices in frames to one (unicast) or all (broadcast) network nodes.

The wireless bootloader resides in bootloader section of the network nodes and occupy about 1K words of programm memory. Additionally to the bootloader code, configuration record at the end of the bootloader section. This record ensures that the node address and channel information is available, even if the EEPROM was accidentally erased.

The network nodes are passive, that means they never send anything if not queried by the host node.

2 Quick Start

1. Compile the firmware images `wibo_<node>.hex`, `wibohost_<host>.hex`, `xmpl_wibo_<node>.hex`

2. Flash wibo_<node>.hex together with the configuration record to the network nodes.
3. Set "BOOTRST" fuse on the network nodes to jump per default into bootloader.
4. Flash wibohost_<board>.hex on the host node
5. Connect the host node with the PC
6. Run the programm wibohost.py on the PC and e.g. flash all nodes with a app.hex

```
python wibohost.py -P <SPORT> -A 1:16 -U app.hex
```

3 The Bootloader Application

Build and Flash Build the bootloader for your board with the command

```
make -C ../src <board>
make -f wibo.mk <board>
```

With the command `make -f wibo.mk list` the available <board>s are displayed.

The bootloader expects an address record at the end of the flash memory section. This record can be generated with the script `nodeaddr.py`. Here is an example for the rdk230 board.

```
# generate a hex file with the configuration record for node #1
python nodeaddr.py -a 1 -p 1 -c 11 \
    -f ../bin/wibo_rdk230.hex -B rdk230 -o a1.hex

# flash node #1 (SHORT_ADDR=1)
avrdude -P usb -p m1281 -c jtag2 -U a1.hex

# Fuses for initial jump to bootloader
avrdude -P usb -p m1281 -c jtag2 -U lf:w:0xe2:m \
    -U hf:w:0x98:m -U ef:w:0xff:m
```

To verify the correct AVR fuse settings refer to <http://www.engbedded.com/fusecalc>.

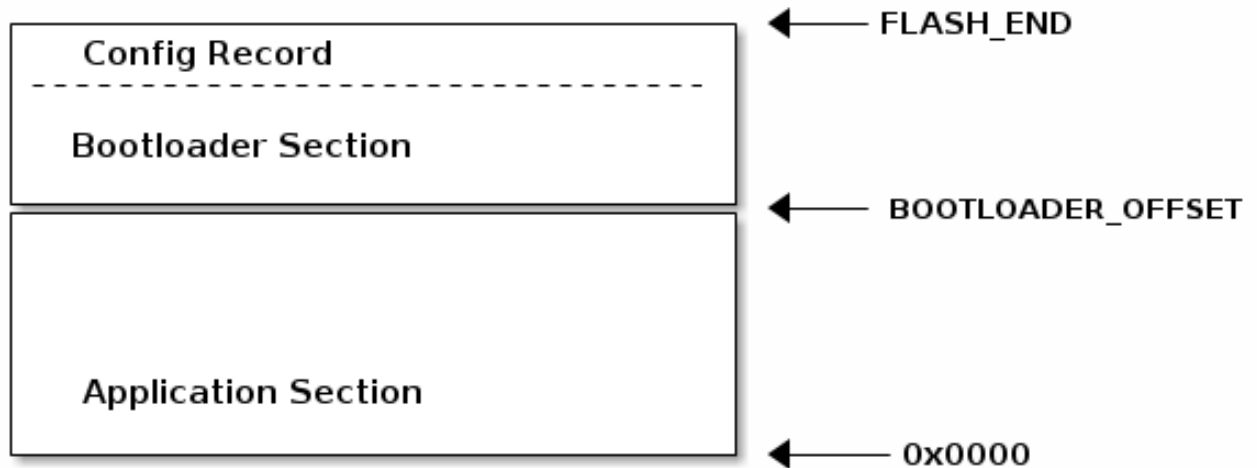
To flash multiple nodes more efficiently, the `nodeaddr.py` can pipe its output directly into `avrdude`. This slightly more complex command line can be stored in script `flashwibo.sh` (under Windows replace `$1` by `%1` for `flashwibo.bat`):

```
python nodeaddr.py -a $1 -p 1 -c 11 -f ../bin/wibo_rdk230.hex -B rdk230 | \
    avrdude -P usb -p m1281 -c jtag2 \
        -U fl:w:-:i -U lf:w:0xe2:m -U hf:w:0x98:m -U ef:w:0xff:m
```

Note: The option "-p 1" set the IEEE PAN_ID to "1" and must be identical for the bootloader application and the wibohost application.

With the `python nodeaddr.py -h` the help screen is displayed.

Flash memory partitioning The AVR flash memory can be divided in an application and a bootloader section. The application section is located in the lower address memory. The bootloader section is located in the upper flash memory. In this section the so called self programming opcodes (SPM) can be executed by the AVR core. This SPM opcodes allows erasing and reprogramming the application flash memory.



The start address of the bootloader section is determined by the `BOOTLSZ` fuse bits. The `BOOTRST` fuse bit determines, if the AVR core jumps after reset to the application section (address `0x0000`) or to the bootloader section (e.g. address `0xf000`). The AVR fuse bits and the content of the bootloader section can only be changed either by ISP, JTAG or High Voltage programming.

In order to have enough memory for the application available, the bootloader section is chosen to be rather small, e.g. for 8K devices a 1K bootloader section and 7K application section is a reasonable choice. The larger 128k AVR devices are partitioned usually with a 4K bootloader section, leaving 124K flash memory for the application.

The Configuration Record at FLASH_END For WiBo, the last 16 byte of the flash memory are reserved for a configuration record, that holds address and channel parameters, which are needed for operation. The structure of this record is defined in file `board.h` in the type `node_config_t`. It stores

- 2 byte `SHORT_ADDRESS`
- 2 byte PAN ID
- 8 byte `IEEE_ADDRESS`
- 1 byte channel hint
- 2 reserved bytes
- 2 byte CRC16

The configuration record is accessible from the application and from the bootloader section.

4 The Host Application

Build and Flash Here is an example for the Raven USB Stick. Applying the configuration record to the hex-file is done in the same manner as for the bootloader application.

```
cd wibo
make -C ../src rzusb
make -f wibohost.mk rzusb
python nodeaddr.py -a 0 -p 1 -c 11 -f ../bin/wibohost_rzusb.hex -B rzusb -o h.hex
avrdude -P usb -c jtag2 -p at90usb1287 -U h.hex
```

Note: The option "-p 1" set the `IEEE PAN_ID` to "1" and must be identical for the bootloader application and the wibohost application.

5 Python Host Application

Using wibohost.py To test the wireless bootloader environment, the `xmpl_wibo` application will be used. It blinks a LED with a certain frequency and is able to jump in the bootloader when the special "jump_to_bootloader" frame is received.

At first create some firmware versions, e.g. one slow and one fast blinking. The network nodes shall be `rdk230` nodes.

```
make -f xmpl_wibo.mk BLINK=0x7fffUL TARGET=slow rdk230
make -f xmpl_wibo.mk BLINK=0xffffUL TARGET=fast rdk230
```

Next assume that you have 4 network nodes with addresses [1,2,3,4]. In order to check the presence of the nodes, run the scan command.

```
python wibohost.py -P COM1 -S
```

Note that the default address range of `wibohost.py` is 1 ... 8. This can be modified with the `-A` option. In the example above, only the nodes 1 to 4 are present, therefore no response from the nodes 5 ... 8 is received.

At first we update all nodes with the slow blinking firmware. Therefore we use the broadcast mode (`-U`), that means that the image is transferred only once over the air. The address range (`-A`) is needed to ping the nodes before programming and afterwards to verify their CRC.

```
python wibohost.py -P COM1 -A1:4 -U slow.hex
```

In the next step we selectively flash node 1 and node 3 with the file `fast.hex`. Since we use unicast programming (`-u`), the image is transferred for each node over the air separately.

```
python wibohost.py -P COM1 -A1,3 -u fast.hex
```

The WiBoHost API The file `wibohost.py` can also be used as a python module. The following script shows how a broadcast and a unicast flash can be programmed.

```
from wibohost import WIBOHost

wh = WIBOHost()
# open serial connection to wibohost node
wh.close()
wh.setPort("COM19")
wh.setBaudrate(38400)
wh.setTimeout(1)
wh.open()
# check if local echo works.
print WHOOST.echo("The quick brown fox jumps")

# scan addresses 1 to 4
addr_lst = wh.scan(range(1,4+1))

# broadcast mode, flash all nodes
for n in addr_lst:
    wh.xmpljbootl(n)
    print "PING :", n, wh.ping(n)

print "FLASH :", wh.flashhex(0xffff, "foo.hex")
for n in addr_lst:
    print "CRC :", n, wh.checkcrc(n)
    print "EXIT :", n, wh.exit(n)

# unicast mode, flash node 1
wh.xmpljbootl(1)
print "PING :#1", wh.ping(1)
print "FLASH :#1", wh.flashhex(1, "bar.hex")
print "CRC :#1", wh.checkcrc(1)
print "EXIT :#1", wh.exit(1)
```