White Rabbit Switch: software build scripts

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How to rebuild the whole software package from sources

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Introduction

This document describes the software build procedures for the White Rabbit Switch. The procedure described is for version 3 of the hardware project, which has been successfully booted for the first time on Sep 13th 2011. The different steps focus on the v3.3, however you can find some (though limited) documentation for v3.0, v3.1 & v3.2 in Appendix B [Older Hardware Releases], page 16

Note: the switch, as shipped, works perfectly with the provided binaries (`http://www.ohwr.org/projects/wr-switch-sw/files`), and most users will only need to run the flasher – see Chapter 3 [Flashing of WRS-3], page 5. This document as a whole is mainly aimed at developers who want to customize their own switch, which is actually a GNU/Linux host.

If you do not need to modify/hack anything in the switch and just learn how to use it, you should first refer at the **User Guide** that you can find in the `http://www.ohwr.org/projects/wr-switch-sw/files`

If you have an older Version-2 switch, please refer to the v2 branch of the repository at `git://ohwr.org/white-rabbit/wr-switch-sw.git` (or `git@ohwr.org:white-rabbit/wr-switch-sw.git` if you are granted write access).

1 Overview

The scripts build over previous work by Tomasz Wlostowski, who first made the whole thing work and stick together – a serious result from serious efforts, I am really amazed by his achievements.

The purpose of the build-script rewrite is achieving the following targets:

- One-command build. The non-technical user should be able to rebuild the whole software package with a single command. This includes the IPL and boot-loader even though they are expected to be pre-installed in the switch with no real need for upgrading.
- Sub-package separation. Users and developers should be able to rebuild each sub-package by itself. Sub-packages are the kernel, *buildroot*, libraries and so on. If you have a problem (or a customization you need on one sub-package), you should be able to work on the specific part ignoring the whole as much as possible.
- Documentation. The steps are documented as much as possible, because mishaps do happen, and you should easily understand where the problem is.
- Avoid redundant downloads. People with non-mainstream network connections would rather avoid downloading the same package over and over. Thus, a centralized download directory is defined where all external packages are retrieved. Even if you "make distclean" in the build scripts you will not need re-get everything from the network. In a similar mood, people who already have a local copy of the big packages (kernel, barebox, white-rabbit svn) will not need to re-download not even the first time they build the WRS software.

The build system is set up as a mix of scripts and makefiles. Every sub-package is built by its own script and/or Makefile, and configuration is passed over through environment variables. The top-level build script sets all environment variables, while keeping defaults from your preexisting environment – so you can override anything even when rebuilding it all from scratch.

1.1 Portability

The scripts in their current status are not expected to be very portable. I am sure a number of *bashisms* exist, and I did no effort to even identify them. To relieve the user from possible pain, internally the name *bash* is used instead of *sh*, so things should work even if your default shell is *ash* or *dash*.

Similarly, the scripts are likely to fail if you use spaces in directory names; that is because not all uses of shell variables are properly quoted. I urge you to use directory names with no spaces in them, or to submit a patch to fix the scripts.

It should go without saying that the build environment is expected to be a native GNU/Linux system; success reports about other environments (e.g. cygwin) are welcome, possibly with associated patches.

1.2 Environment Variables

The scripts use a number of environment variables; you can pre-set them as you wish. If they are not pre-set, defaults apply as described below.

When rebuilding everything, the defaults are applied for each unset variable; but when rebuilding a sub-package you will need to set the variables beforehand. Each sub-package complains if it needs variables that are not set in your environment.

The following variables are used in one or more parts of the scripts; let me restate, though, that sensible default values apply by default, so this list is mainly for your curiosity unless you are a developer.

They are listed in an order that seems logical to me, but may sound random to a different person, please forgive this. Most of the variables are prefixed with `WRS_` to make them easily identified in the overall mess of variables and command names (all scripts used here have a similar prefix for the same reason).

`WRS_BASE_DIR`
: The absolute pathname of the build directory (i.e., the `build/` subdirectory of `wr-switch-sw`). The variable is internally set to the directory name of the main script. Note that the script cannot be run from the same directory or from the wr-switch-sw project directory (i.e.: `./wrs_build-all ./build/wrs_build-all` are not allowed), you must call it from your output directory using a pathname to invoke it. This variable cannot be overridden in the main script, but must be pre-set if you run a sub-script to rebuild only part of the software suite.

`WRS_OUTPUT_DIR`
: The absolute pathname of the directory where output is placed. It defaults to the current directory whence you invoke the script (i.e., you can invoke `/path/to/wrs_build-all` to have all output in the current directory). Compilation happens in a *build* subdirectory of `WRS_OUTPUT_DIR`, done-markers are placed in a *_done* subdirectory and final images are placed in a *images* subdirectory.

`WRS_DOWNLOAD_DIR`
: The absolute pathname of the directory where downloaded files are placed. If unset it defaults to `$WRS_OUTPUT_DIR/downloads`, which is created if needed. By pre-setting this variable you can simply recursively delete the output directory to force a full rebuild, without the overhead of re-downloading everything.

`WRS_HW_DIR`
: The absolute pathname of the directory where you build HDL, if any. If this variable is set, FPGA binaries will be copied from there instead of being extracted by the official archive on `owhr.org`.

`CROSS_COMPILE`
: The variable is the usual cross-compilation prefix. For example, `arm-linux-` if you have *arm-linux-gcc* in your path, or a full pathname without the trailing `gcc`. If unset, it defaults to the compiler that *buildroot* self-builds. See Section 5.1 [The Compiler], page 10 for some more details.

Other variables are used internally in the script; since they are only useful to people working on the script itself, they are documented in place.

If you compiled for version 2 you will notice we do not have `WRS_WR_REPOSITORY` any more. We used to rely on upstream archives to be part of the *White Rabbit* subversion tree, but I did not add the new archives in there because of their size.

1.3 Downloading Files

Every downloaded file is saved to the `download` directory (if set `WRS_DOWNLOAD_DIR` else the default `$WRS_OUPUT_DIR/downloads`). You should arrange not to remove that directory when you recompile over and over during development. I chose to make the first script download everything, because I think this eases development in a way: you first wait a while but can tell download errors from other issues, and then you can build it all even without a network connection.

For each upstream archive needed, the following steps are performed:

- If the file exists in the download directory, the *md5sum* is checked; on success, nothing else is done.
- If the previous step fails, the file is retrieved from upstream.
- If the previous step fails, the file is downloaded from the buildroot web site.

The policy just described is implemented in *wrs_download*, in the file `scripts/wrs_functions`, based on `download-info` in the main build directory.

The messages of a download run are like the following ones:

```
2012-01-12 18:30:46: --- Downloading all files
2012-01-12 18:30:53: Retrieved at91bootstrap-3-3.0.tar.gz from upstream
2012-01-12 18:31:00: Retrieved buildroot-2011.11.tar.bz2 from upstream
[...]
2012-01-12 18:37:53: Retrieved uClibc-0.9.32.tar.bz2 from upstream
2012-01-12 18:37:56: Retrieved zlib-1.2.5.tar.bz2 from upstream
```

2 Building

2.1 Building Procedure

If you just want to build stuff, with no concern about network downloads and without even knowing what is happening, just create a directory where you want the output to be generated and start compilation. Note that it takes around 3GB of storage.

Then run this (but please read more for a better command):

```
/path/to/wr-switch-sw/build/wrs_build-all
```

Note that progress messages are sent to *stderr*, so you may want to save *stdout* to a file, like this (again, it is recommended you read further for a better command):

```
/path/to/wr-switch-sw/build/wrs_build-all > logfile
```

Please note that there are also a number of warning messages being printed to *stderr*. It is a few hundred lines over the many minutes it takes to build *buildroot*, but you can safely ignore them, trusting the build process will complete successfully.

The progress messages look like what is shown here below. The log file will be rather big (6 or 7MB or so), as all the compilation steps are quite verbose.

The following example shows a run on a quad core system (18k bogoMips in total). If files had already been downloaded, the first step takes only a pair of seconds to verify the checksums:

```
2012-07-06 17:23:57: --- Downloading all files
2012-07-06 17:24:02: --- Buildroot compiler and filesystem
2012-07-06 17:24:02: Uncompressing buildroot
2012-07-06 17:24:02: Patching buildroot
2012-07-06 17:24:02: Reconfiguring buildroot
2012-07-06 17:24:04: Compiling buildroot
2012-07-06 17:48:46: --- AT91Boot
2012-07-06 17:48:46: Patching AT91Boot
2012-07-06 17:48:46: Building AT91Boot
2012-07-06 17:48:50: --- Barebox
2012-07-06 17:48:50: Patching Barebox
2012-07-06 17:48:50: Building Barebox
2012-07-06 17:48:59: --- Linux kernel for switch
2012-07-06 17:50:32: --- Kernel modules from this package
2012-07-06 17:50:35: --- PTP daemon (noposix repository as a submodule)
2012-07-06 17:50:38: --- User space tools
2012-07-06 17:50:39: --- Deploying FPGA firmware
2012-07-06 17:50:39: --- Wrapping filesystem
2012-07-06 17:50:53: Complete build succeeded, apparently
```

You may prefer to save *stderr* with *stdout* to the log file but still see the time-stamped messages from the scripts. In this case you can issue the following command – which is what I used to generate the terse output shown above:

```
/path/to/wr-switch-sw/build/wrs_build-all 2>&1 | tee logfile \
     | grep "^20..-..-.. ..:"
```

If you are lucky, everything completes by itself. The time taken depends on you CPU, disk and network speed. At the end you will find your final files in the `images` subdirectory. If you are not too lucky, the build stops because you have found a bug in the build scripts; most likely because your setup differs from the ones we have been testing on.

In order to re-run the build from the beginning, please remove (or rename) the output directory and reissue the command. To only redo one step, you can remove the marker in `build/_done` (the markers are empty files with name like `01-buildroot` and `04-kernel`).

2.2 Build Script Description

The `wrs_build-all` can be used to quickly build the White Rabbit Software as seen above. However it admits other functionalities detailed in this chapter. You might also want to check its embedded documentation using:

```
/path/to/wr-switch-sw/build/wrs_build-all --help
```

2.2.1 Release Package

Once all the building steps have succeeded, you can easily create a package in `WRS_OUTPUT_DIR` using the following command:

```
/path/to/wr-switch-sw/build/wrs_build-all --pack
```

This will generate a `tar.gz` package. The name of the package is composed by the prefix and the description of the current status of the git repository. This is the same naming policy of the kernel and other packages.

The prefix is `wrs-firmware-`; the information about the current status are retrived by using the git commmand `git describe --always --dirty`. For example, if you are building the tag `wr-switch-sw-v3.3`, your package name will be `wrs-firmware-wr-switch-sw-v3.3.tar.gz`. If you are building on some personal commit the name includes some extra information to describe your commit: number of commits form the last tag (if any), SHA1 code of the commit. If you have uncommited changed, the suffix `-dirty` is there too.

2.2.2 Rebuilding Parts

When the main script succeeds in building one part (sub-package), it creates a file in the `build/_done` directory.

When you rebuild everything, steps for which the marker file exists are not rebuilt. To force rebuilding of one specific part, just remove the marker. Markers are numbered, reflecting the order of compilation steps, but they also have a name: names like `04-kernel` should be self-explicative.

To ease the rebuilding of a specific module a shortcut has been created in the `wrs_build-all` script. For example if you want to recompile kernel you should execute.

```
/path/to/wr-switch-sw/build/wrs_build-all --step=04
```

You can list all compiled module by calling

```
/path/to/wr-switch-sw/build/wrs_build-all --list
```

If you want to rebuild various modules at the same time, you should run something similar as:

```
/path/to/wr-switch-sw/build/wrs_build-all --step="5 7 9"
```

As an alternative, you can run the individual script from within *scripts/*, after setting the proper environment variables.

2.2.3 Rebuilding From Scratch

If you have updated the repository with new modifications, you might want to check that you can rebuild from scratch. To clean your output directory by deleting all compiled modules (except downloaded files), just call:

```
/path/to/wr-switch-sw/build/wrs_build-all --clean
```

3 Flashing of WRS-3

This chapter describes the different steps to install the WRS-3 with the correct firmware. This procedure describes the installation of the switch with a *SCB v3.3* and a *Mini-Backplane v3.3*. If you have an older version you might look at the Appendix B [Older Hardware Releases], page 16 and the footnotes.

3.1 USB connections

In order to perform the flashing operation easily, you should connect three *mini-USB* cables to the switches.

The two back panel *mini-USB* sockets correspond to the serial port of the FPGA and the ARM. They are labeled **FPGA test** and **ARM test** and respectively correspond to the devices `/dev/ttyUSB0` and `/dev/ttyUSB1` on your host.

You can connect to them using minicom[1] like this:

```
minicom -D /dev/ttyUSB0 -b 115200
minicom -D /dev/ttyUSB1 -b 115200
```

Unfortunately, this order depends on how the USB cables are plugged so you might have the `ttyUSB0` device that corresponds to the ARM and the `ttyUSB1` to the FPGA.

The front panel USB connection, labeled as **managment** USB port, communicates with the internal ROM of the CPU. It is the one used to perform the flashing procedure.

[1] You can use other programs for accessing serial ports, for example tinyserial

You first need to set up the switch in "*Flashing mode*" to continue with the flashing procedure. To do so, you should turn on the power while pressing the **flash button** on the rear panel.

If the operation succeed you should see the message `bootROM` appears on the ARM UART. You can also see the enumerated device in your own host:

```
$ lsusb | grep Atmel
Bus 001 Device 025: ID 03eb:6124 Atmel Corp. at91sam SAMBA bootloader
```

Finally, the kernel should also load the proper device driver, and you are expected to see `/dev/ttyACM0` or equivalent in your system.

If it is not the case, this mean that the buton used to disable the dataflash during the boot so that the CPU ROM do not find any valid code and enter in "*Flashing mode*" is not working. You can open your box and follow the instruction explained Section B.1.1 [Flashing v3.2], page 17 or contact support.

Please note that this procedure is not available with the previous version. Refer to your corresponding flashing section in Appendix B [Older Hardware Releases], page 16.

3.2 Flashing Procedure

The tool used to flash the firmware into the switch is the *USB-loader* we inherited from Atmel. The '`flash-wrs`' script is what you'll use to run the loader with appropriate parameters.

The script can be invoked in the following way to flash a *package* into the switch. The package is the `.tar.gz` file created by "`wrs_build-all --pack`" (see Section 2.2.1 [Release Package], page 4).

The command to flash is this:

```
/path/to/wr-switch-sw/build/flash-wrs -e wrs-firmware-<revision>.tar.gz
```

You can also flash the image you have build using Chapter 2 [Building], page 3 by adding the tag `-b|--build`. To use this option you must call the script from the build directory, or define the `WRS_OUTPUT_DIR` environment variable.

```
/path/to/wr-switch-sw/build/flash-wrs -e -b
```

Please note that the "`-e`", which requires erasing the whole data flash, is almost mandatory because otherwise bits of your previous installation may leak into the newly-programmed one. Only on factory-new devices you can avoid this "`-e`" argument.

When you program the NAND memory the script applies automatically `-e` option.

It is recomended to configure the MAC addresses during the flashing procedure. With the option `-m1|--mac1` you can select the MAC address to assign to the Ethernet port on board. With the option `-m2|--mac2` you can select the base MAC address; the `wr_nic` driver will use this MAC address to sequentially assign a MAC address for every switch ports.

```
/path/to/wr-switch-sw/build/flash-wrs -e -b -m1 02:34:56:77:65:43
-m2 02:34:34:34:34:00
```

Please remember that bits 0 and 1 of the first byte are special: if the first byte is odd, the MAC address is reserved for multicast transmission (the script doesn't check, and the kernel will refuse to enact such address). Bit 1 is set for "locally assigned" numbers: while official MAC addresses have bit 1 clear, if you choose your unofficial addresses you should set the bit.

If you don't configure a MAC address, a warning will be displayed and you can abort the procedure. If you don't abort the flashing procedure, the script will use default MAC addresses. Default MAC addresses are: 02:34:56:78:9A:BC for MAC1 (the Ethernet port of the ARM CPU) and 02:34:56:78:9A:00 for MAC2 (the base address for the 18 SFP ports).

```
tornado% ~/wip/wr-switch-sw/build/flash-wrs -e -b
flash-wrs: Working in /tmp/flash-wrs-1vV9z6
Warning: you did not set the MAC1 value; using "02:34:56:78:9A:BC"
Warning: you did not set the MAC2 value; using "02:34:56:78:9A:00"
```

```
flash-wrs: I'm talking with the switch;
   please remove the jumper and press Enter to start flashing:
```

If the script cannot find the Atmel programming interface on your USB bus, it prints a message and waits for the switch to be turned on in the proper way (with the humber plugged).

The process calls the flasher program twice (so you'll see the initialization strings two times) and takes slightly less than 3 minutes. the longest step is erasure of *DataFlash*: if run without `-e` the script takes just 20 seconds.

This is the summary of the output you are expected to see, trimmed to save pages:

```
Initializing SAM-BA: CPU ID: 0x819b05a2

[...]

Initializing DDR...
loading applet isp-extram-at91sam9g45 at 0x00300000
Initializing DDR > Done

Initializing DataFlash...
loading applet isp-dataflash-at91sam9g45 at 0x00300000
Initializing DataFlash > Done!

Erasing DataFlash [... there is a long delay here ...] > DONE

Programming DataFlash...
  0x70000000 : at91bootstrap.bin ; size 0xf7c (3Kb)
DataFlash: Writing 3964 bytes at offset 0x0 buffer 70000000....ABCDEF OK
  0x70008400 : barebox.Fb09jx ; size 0x2f1bc (188Kb)
DataFlash: Writing 192956 bytes at offset 0x8400 buffer 70000000....ABCDEF OK
Programming DataFlash Done!!!
[...]

Initializing NandFlash...
loading applet isp-nandflash-at91sam9g45 at 0x00300000
Initializing NandFlash > Done!

Erasing NandFlash > DONE

[...]

Initializing DDR...
loading applet isp-extram-at91sam9g45 at 0x00300000
Initializing DDR > Done

Erasing DDR > DONE

Loading DDR...
  0x70000000 : /tmp/barebox.Fb09jx ; size 0x2f1bc (188Kb)
  0x71000000 : /data/morgana/build-v3-fede/images/zImage ; size 0x16886c (1442Kb)
  0x71fffff8 : /tmp/wrsflash-cpio.jrPKMY.cpio.gz ; size 0x128c722 (18993Kb)
DDR: Writing 21119306 bytes at offset 0x0 buffer 70000000....ABCDEF

[...]
```

It is suggested to look at the CPU's serial port during programming, where you will see messages like these:

```
-I- Statup: PMC_MCKR 1202 MCK = 100000000 command = 0
-I- -- EXTRAM ISP Applet 2.9 --
-I- -- AT91SAM9G45-EK
[...]
-I-     End of applet (command : 2 --- status : 0)

[...]
```

```
barebox 2012.05.0 (Oct 26 2012 - 20:51:43)

Board: CERN White Rabbit Switch V3

[...]

Uncompressing Linux... done, booting the kernel.

[...]

FLASHING: flashing kernel to /dev/mtd0 ...
Writing data to block 0 at offset 0x0
Writing data to block 1 at offset 0x20000

[...]

FLASHING: flashing file system to /dev/mtd1 ...
Writing data to block 0 at offset 0x0
Writing data to block 1 at offset 0x20000

[...]
```

3.2.1 Flash Script Description

The `flash-wrs` script can be used to quickly flash the White Rabbit switch as seen above. However it admits other functionalities detailed in this chapter. You might also want to check its embedded documentations using:

```
$ ./build/flash-wrs --help
Usage: ./build/flash-wrs [options] [<firmware>.tar.gz] [DEV]

MAC:  MAC address in hexadecimal seperated by ':' (i.e, AB:CD:EF:01:23:45)
<firmware>.tar.gz: Use the file in the firmware to flash the device
DEV:  The usb device (by default it is /dev/ttyACM0)
Options:
  -h|--help  Show this help message
  -m|--mode  can be: default (df and nf), df (dataflash),
 nf (nandflash), ddr (ddr memories).
  -g|--gateware  Select the gateware: 18p (18 ports, default), 8p (8 ports), LX130T (small FPGA), LX240T
  -e   Completely erase the memory (Can erase your configuration)
  -b|--build  Use files that you have built in the WRS_OUTPUT_DIR
  -m1|--mac1  Default MAC address for the ethernet port on board
  -m2|--mac2  Default base MAC address for the switch ports
```

The *DEV* is optional and the default is `/dev/ttyACM0`. If your system maps the Atmel ROM to a different device name, please pass the name on the command line. The script wants a full pathname starting with `/`.

If you want to flash the *at91boot.bin*, *barebox.bin*, *kernel* or *file-system* that you just built, you can just call the script from the build directory and use the `-b` option.

The official binaries for installation of version 3.3 of this package are available in the *files* tab of `ohwr.org`. The complete link is:
www.ohwr.org/attachments/download/2262/wr-switch-sw-v3.3-20130725_binaries.tar.gz

You can select a mode using the `-m|--mode` flag to choose to write in dataflash (df), nandflash (nf), both (default) or ddr memories (ddr)[2]. The memory mode is used to select the kind of memory to write. The flash script is used to install different binaries on these memories:

- dataflash: *at91boot* and *barebox* binaries

[2] The ddr memory mode is only for developers

- nandflash: *kernel* zImage and the *file-system*

You can select which type of gateware you want to flash on your switch. By default we only write on the nandflash the gateware for 18 ports for both its light (`LX130T`) and full (`LX240T`) FPGA size. If you know which type of FPGA you are using (i.e, `LX240T`) and you want to have the gateware for 8 and 18 ports you can use the flag as below:

```
$ ./build/flash-wrs --gateware LX240T <...>
```

You can also erase the dataflash memory before writing your binaries; to do this add the option `-e`. Note that the script always erases nandflash before writing to it.

The script performs the following steps:

- It compiles the loader (*usb-loader/* subdir).
- It checks if the SAMBA bootloader is present.
- It picks the correct binaries according to the options.
- Optionally, it changes the default MAC addresses in *barebox* default environment, so you can use a different MAC for each switch.
- Optionally, it erases the dataflash memory.
- And finally, it writes the corresponding binaries to *dataflash*, or *nand*.

4 Booting with Barebox

After the initial installation, the boot loader will offer you an interactive menu, where the first entry is selected by default. The menu is a simple ASCII interface on the serial port, and looks like the following:

```
Welcome on WRSv3 Boot Sequence
    1: boot from nand (default)
    2: boot from TFTP script
    3: edit config
    4: exit to shell
    5: reboot
```

If flashing of the whole system was successful, the first entry will simply work, booting the switch without any network access. Although a DCHP client runs by default after boot, everything will work even if you leave the Ethernet port unconnected or you have no DHCP server when the switch is operational.

If booting from NAND memory fails (for example because you erased the kernel partition) the menu is re-entered automatically.

The other entries are provided to help developers.

4.1 Description of the menus

The individual menu items perform the following actions:

`1: boot from nand (default)`
: This entry is selected by default after 10 seconds of inactivity on the serial port. It boots the system from its own NAND memory. This "just works".

`2: boot from TFTP script`
: This entry tries to download a *barebox* script from your TFTP server; if successful it then executes it. Developers are expected to customize the script to support any kind of environment, from customized kernel command-line to NFS-Root environments. See Section 4.2 [Using wrboot], page 10 for details.

`3: edit config`
: This fires the editor on the configuration file, and saves it to flash when the user is done. This is useful to change the MAC address of the ARM network port. Please note that saving save the whole '`/env`' file tree, so you can also change the init scripts interactively and have them stored persistently on the flash.

`4: exit to shell`
: By choosing this entry, the user can access the shell-like interface of *barebox*. The entry is aimed at developers who know what they are going to type.

`5: reboot`
: This entry is useful to see and log the exact boot messages. Since the serial-USB converter is *switch-powered* and not *USB-powered*, you won't be able to hook at the serial port soon enough after power-on. Actually, the menu timeout is left to 10 seconds and not less for the very same reason.

4.2 Using wrboot

If you use the *wrboot* script option, you can for example run an NFS-Root system or do whatever customization and testing you want.

The provided procedure tries to load the script from TFTP under three different names, from most specific to most generic, and the first match will be used. The first name is MAC-address-based, the second is IP-address-based and the third is just '`wrboot`'.

This is for example what I see in my logs when only providing '`wrboot`':

```
dhcpd: DHCPOFFER on 192.168.16.224 to 02:0b:ad:c0:ff:ee via eth0
atftpd[5623]: Serving wrboot-02:0B:AD:C0:FF:EE to 192.168.16.224:1029
atftpd[5623]: Serving 192.168.16.224/wrboot to 192.168.16.224:1030
atftpd[5623]: Serving wrboot to 192.168.16.224:1031
mountd[21014]: NFS mount of /tftpboot/192.168.16.9 attempted from 192.168.16.9
```

We chose to place the IP-address-based name in a subdirectory because this is the default place where the NFS-Root filesystem is mounted from, as shown in the log excerpt above. So you'll have your '`wrboot`' in the same place

The '`binaries`' subdirectory of this package includes two known-working wrboot scripts as examples; one if for use with static IP addresses and the other relies on DHCP. If you want to override the default NFS-Root directory mounted from the server (which is `/tftpboot/<ip-address>`) you can add something like the following line to your '`wrboot`' script:

```
bootargs="$bootargs nfsroot=/opt/root/wrs-3"
```

If you use static IP addresses, please note that you should fix '`/etc/init.d/S40network`' in the filesystem for your switch, so it doesn't run the DHCP client.

5 The Individual Build Steps

This chapter details the individual build steps, for the users that want to customize their switch in any way.

5.1 The Compiler

The predefined compiler used here is the one built by *buildroot*. The default configuration selects this choice. If you pre-set a different `CROSS_COMPILE` prefix in your environment, your own choice will be used by modifying the *buildroot* configuration file. Note, however, that not all cross-compilers will work (*buildroot* wants one that has been configured with `--sysroot` and it is quite unlikely yours has been).

In practice, you may want to set `CROSS_COMPILE` when you compile the boot loader and kernel by themselves, and avoid it when compiling the complete package.

5.2 Buildroot

The distribution being used here is *buildroot*. It is the first step being built, because it creates the cross-compiler it will use. This compiler is later used to compile all other software for the White Rabbit Switch.

The configuration for *buildroot* comes from `patches/buildroot/buildroot-config-wrswitch`. The configuration is then changed only if you pre-set your own `CROSS_COMPILE` variable.

If you want to change the configuration, you can do so after the first build iteration: change directory to `build/buildroot-2011.11` and run `make menuconfig`. After making your choices, copy back the file `.config` to `patches/buildroot/buildroot-config-wrswitch` in this package.

You can also set `WRS_BUILDROOT_CONFIG` to the full pathname of your configuration file of choice. The file must be a copy of the `.config` after the `make menuconfig` step described above. Note that if the variable is not pointing to a regular file it is ignored with a simple warning – rather than stopping the build procedure.

5.3 The IPL

The version of *at91bootstrap* being used in the switch as *Initial Program Loader* is version 3.3, download from `timesys.com/` (the full URL is in *build/download-info*. The patches we applied are in the directory *patches/at91boot/v3.3*, and we are piggy-backing on the Atmel evaluation board without even changing the board name):

```
0001-printf-added-files-from-pptp-unchanged.patch
0002-printf-fixes-and-addition-to-makefile.patch
0003-build-Add-gitversion-to-binary-and-a-script-to-compi.patch
0004-board-9g45ek-fix-ddr-config-for-WRS-V3.patch
0005-boot-disable-watchdog-asap-added-flip_leds-count-run.patch
0006-boot-Correct-crash-due-to-an-Atmel-bug-during-boot-w.patch
0007-gpios-Correct-FPGA-LED-problems-and-add-CPU-LEDs-FAN.patch
```

The script *wrs_build_at91boot* uncompresses, patches and builds, leaving `images/at91bootstrap.bin` after it is over. This file is the one to be loaded in the hardware. For simplicity, a known-working binary is part of the *binaries* directory of this package as `at91bootstrap.bin`, the same name used later in the installation instructions.

If you build using a local *git* repository, we suggest to use `git am --whitespace=nowarn` because we have a number of white space errors, and we apologize for that.

Warning: with most distributions, this compilation step will print a scary message about memory corruption. The message is reporting a bug in the configuration program which has no actual effects and can be ignored. Maybe we will switch to another version in the future that doesn't show the bug, or to the newer *barebox* that obsoletes *at91boot*.

5.4 The Boot Loader

The switch uses *barebox* as a boot loader. We are running version 2012-05, with a few local patches and the chosen configuration file. Note that we are piggy-backing on the Ronetix PM9G45 board, out of laziness.

The patches are part of this package in *patches/barebox* and the set is made up of the following ones:

```
0001-sam945-include-mtd-nand.h-in-device-file.patch
0002-arm-change-prompt-for-pm9263-wrs-piggy-backs-on-that.patch
0003-nand-wrs-our-nand-is-16-bit-connected-fix-accordingl.patch
0004-add-DHCP-retries-by-tom.patch
0005-gpio-add-function-to-check-them.patch
```

```
0006-startup-load-default-environment-when-loading-env-fa.patch
0007-wrs-on-pm9g45-change-nand-setup.patch
```

If you build using a local *git* repository, we suggest to use `git am --whitespace=nowarn` because we have a number of white space errors, and we apologize for that.

The *barebox* boot loader is organized as a small Unix-like environment, and its own configuration and scripts live in a small filesystem. To ease modification of such configuration and boot steps the build script copies over the configuration instead of patching it in the sources. You can thus edit the files you find in '`patches/barebox/env`' and rebuild your customized bootloader. The script that is executed at boot time is '`env/bin/init`' and as you see it calls the other ones. The menus included in the shipped configuration are described in Chapter 4 [Booting with Barebox], page 9.

Building *barebox* relies on a *Kconfig* setup, and the configuration file we use is '`patches/barebox/wrs3_defconfig`'. Again, this is copied over and not patched in (see the simple '`build/scripts/wrs_build_barebox`' for details).

After patching and copying over the files, the following commands build the boot loader using the cross-compiler built by *buildroot*. If you run these by hand you can use a different compiler (as shown):

```
export CROSS_COMPILE=/opt/arm-2010q1/bin/arm-none-eabi-
export ARCH=arm
make wrs3_defconfig
make
cp barebox.bin images/
```

To use the same compiler the scripts use, you need this setting (which is split in two lines with a local variable to fit the page with in documentation):

```
BR=${WRS_OUTPUT_DIR}/build/buildroot-2011.11
export CROSS_COMPILE=${BR}/output/host/usr/bin/arm-linux-
```

A pre-built binary is available as `binaries/barebox.bin`. The ELF version is copied to *images* as well, as `images/barebox`; this file includes the symbol table and may (or may not) be useful.

5.5 The Linux Kernel

The kernel is currently version 2.6.39, compiled from an uncompressed tar file (so not within a *git* repository). The upstream vanilla kernel is downloaded, then local patches are applied (they come from a *git* repository, but they are currently applied with a simple *patch* command).

The relevant patches are available in *patches/kernel/v2.6.39*, and are currently the following ones:

```
0001-wrs3-changes-to-g45ek.patch
0002-initramfs-stop-after-one-cpio-archive.patch
0003-at91-NR_IRQS-increase-by-64-to-fit-custom-muxes.patch
0004-irq-export-symbols-for-external-irq-controller.patch
0005-fix-nand-parition-layout-and-usb-vbus.patch
0006-fiq-support.patch
```

The configuration we use to build the kernel is not a patch but a plain `.config` file, in the same directory as the patches, so you can change it easily, if needed. As an alternative, you can also set `WRS_KERNEL_CONFIG` to the full pathname of your configuration file of choice. The file must be a copy of the `.config` found in the main kernel directory, (for example the one left after the `make menuconfig` step). Note that if the `WRS_KERNEL_CONFIG` variable is not pointing to a regular file it is ignored with a simple warning, without stopping the build procedure.

The build scripts copy both *zImage* and all compiled kernel modules to the *images/* directory of the build place. This currently includes modules

5.6 Kernel Modules

In the next step the scripts compile modules that are part of this package. The step depends on the kernel being available in the build directory. The modules are then copied into the '`images/wr/lib/modules/`' subdirectory of the main build directory.

Please note that modules (and later user-space) are compiled in-place; ie. not in the output directory. The disadvantage is that your repository becomes dirty with output and intermediate files. The advantage is that any modification you make to the code is already in the repository for your to commit.

Currently, the package includes the following modules:

- *wr_vic.ko*: the interrupt controller for in-FPGA devices.
- *wr-nic.ko*: the network "card" driver for WR ports.
- *at91_softpwm*: a tool that generates a PWM signal for the fan.
- *wr_rtu.ko*: the routing-table interface between the switching core and the associated user-space daemon.

5.7 PTPd

The Precision Time Protocol Daemon being used is hosted in a different repository, but it is registered as a *git* submodule in this package. The repository itself is on `ohwr`, like others. We are working on a better code base for a portable PTP, but it is not yet ready as of this release.

A plain *make* in the *ptp-noposix* directory might fail, because of missing environment variables. because after building *ptpd* other steps are tried, but they are only needed for the freestanding environment (i.e., LM32 with supporting code) and will fail for this *arm-linux* hosted build.

Additionally, the script installs headers for the HAL and *libptpnetif*.

5.8 User Space Applications

The filesystem of the switch includes some user-space applications and tools. Some of the *tools* are actually used by the init scripts and some are just utilities for the developer.

The subdirectories in '`userspace`' include the various applications needed for the operation of the switch itself, as well as support libraries used by the applications themselves.

The main components are:

mini-rpc A remote procedure call library used by most other programs to exchange information among themselves or query the LM32 that is running on the FPGA.

libswitchhw
A series of utility functions to access the switch itself.

wrsw_hal The main application program for the White Rabbit Switch operation. The script installs the executable in `images/wr/bin`.

wrsw_rtud The daemon for the routing table unit, used for routing around data frames. It is installed in `images/wr/bin`.

The most important tools in '`userspace/tools`' are the following:

'`load-virtex`'
'`load-lm32`'
They load into the FPGA the gateware and the LM32 application. They are used by the init scripts of the Linux system.

'`mapper`'
'`wmapper`' The former reads from a file using *mmap* (usually you run it on */dev/mem*) and writes to *stdout*. The latter read from *stdin* and writes using *mmap*. They are classic tools distributed in the *Linux Device Drivers* examples since 1998.

'`com`' The program is a simple program for talking with serial ports.

'`wr_phytool`'
A tool to read and write PHY registers in the switch

'`wr_mon`' A simple monitor of White Rabbit status. It prints to *stdout* using the standard escape sequences.

'`shw_ver`' Print informations about the SW & HW version of the WRS. See also Section A.1 [DIP Switch HW version], page 16.

Please note that to compile the applications and tools outside of the build scripts you need to specify both the kernel directory (`LINUX=`) and the cross-compiler to use (`CROSS_COMPILE=`).

5.9 VHDL and LM32 Binaries

The gateware binaries that are needed to run the FPGA are added to the target filesystem by the '`wrs_build_gateware`' script. If the variable `WRS_HW_DIR` is set, the script uses it to retrieve the binaries you just compiled (but the script is not compiling gateware).

If the variable is not set, the script extract a tar file downloaded from `ohwr.org` as part of the initial download step. The tar is currently called `wrs3-gw-v3.0-20120801.tar.gz` and has been build from the `wr-switch-sw-v3.0` of the `wr-switch-hdl` repository. Please note that the repository uses *git* submodules, so it depends on other `ohwr` repositories too, which in turn have not been tagged because the submodule mechanism ensures you'll get the exact version you need.

The LM32 program is provided as a precompiled binary in `binaries/rt_cpu.bin`. The respective source code is in the '`rt`' directory of this package, but the build scripts don't deal with it to avoid requiring an LM32 development environment.

5.10 The Complete Filesystem

The final step in building the switch software is wrapping together the filesystem for the switch, also making the archives and the *jffs2* image file.

The step of setting up the complete filesystem is performed by '`build/scripts/wrs_build_wraprootfs`'. The script does not leave a directory tree on disk because that would require administrator privileges. We think it is best not to call *sudo* from within build scripts, to respect our users' security concerns.

The script creates three output files, that can be used in different situations, like *initramfs* or unpacking for NFS-Root. All of them are around 15MB of data, and the flashing script only uses the first listed here:

`wrs-image.jffs2.img`
This is a raw image in JFFS2 format, which is ready to be written to NAND flash. This is used bt the USB flasher.

`wrs-image.cpio.gz`
If you prefer to run an *initramfs* system, this is the file you should use. We used it a lot during development, to avoid wearing the flash device and wasting time waiting for the flasher to run.

`wrs-image.tar.gz`
: We added this out of laziness, because it's easier to create your NFS-Root directory from *tar* than from *cpio*.

You can uncompress either *cpio* or *tar*, for example to run NFS-root, by running one of the following commands in a newly-created empty directory:

```
zcat $WRS_OUTPUT_DIR/images/wrs-image.cpio.gz | sudo cpio --extract

tar xzf $WRS_OUTPUT_DIR/images/wrs-image.tar.gz
```

Each of the three archives include a number of device special files in *dev*. The pre-created devices come from *userspace/devices.tar.gz*. Note that the buildroot output directory, *build/buildroot-2011.11/output/target* does not include any device (and no white-rabbit specific files), so it cannot be used as a root filesystem by itself.

The content of the final filesystem comes from several sources:

- The *buildroot* output (from its own '`output/target/`').
- The switch-specific overlay ('`userspace/roofs_override`').
- The '`images/wr`' and '`images/lib`' trees, filled but the build scripts.
- The file '`userspace/devices.tar.gz`'
- The file '`$WRS_BASE_DIR/authorized_keys`' if it exists.

The final step allows a predefined set of users to enter as system administrator without the need to type a password (which, anyways is empty by default). It is useful if you *scp* files in and out of the switch. In the shipped binaries no user is authorized, but the root password is still the empty string.

6 Code layout in a production switch

This final chapter is a summary of how we used the two internal flash memories in the switch, when programmed with the official firmware binaries. It is meant for people who want to better understand the boot procedure and possibly customize stuff using higher-level tools, like erasing and rewriting flash-memory areas from Linux itself.

Unfortunately, the CPU is not able to boot from NAND memory directly, so the first steps of booting are performed from the *dataflash* device. Such an SPI memory is used to host the IPL (*at91boot*) and the executable code of *barebox*. The user is not expected to ever erase this memory; if it happens, the system won't boot and you'll be forced to re-flash it entirely (or at least the *dataflash* area.

NAND memory is used for user-data: tke boot loader configuration, the kernel and the filesystem.

This is how the memory is used. While it definitely looks suboptimal, it is the result of our own history of development and there are no problems with this "strange" split up of space:

```
0x0000.0000 - 0x0004.0000    Empty (space for a barebox)
0x0004.0000 - 0x0008.0000    Barebox environment
0x0008.0000 - 0x0010.0000    Empty
0x0010.0000 - 0x0090.0000    Kernel (plenty of space)
0x0090.0000 - 0x0400.0000    Empty
0x0400.0000 - 0x0c00.0000    Filesystem space, jffs2
0x0c00.0000 - 0x2000.0000    Available
```

When you boot Linux, the three empty areas are not visible, while the last area is accessible. This is the content of '`/proc/mtd`' after boot:

```
dev:    size   erasesize  name
mtd0: 00800000 00020000 "Kernel"
mtd1: 08000000 00020000 "Filesystem"
mtd2: 00040000 00020000 "Barebox Environment"
mtd3: 14000000 00020000 "Available"
mtd4: 00840000 00000420 "spi0.0-AT45DB642x"
```

If you are customizing the switch, you may use the '`flash_erase`' and '`cat`' to replace individual parts of the system, like the kernel, or erase the *barebox* configuration to restore the factory defaults. Note however that you shouldn't modify the *dataflash* device (`/dev/mtd4`) unless you really know what you are doing (for example, the following chapter changes it by using magic offsets in the commands).

Appendix A Schematics are Available

The switch schematics for all PCB versions (3.x of the SCB as well as both 3.1, 3.2 and 3.3 of the backplane) are available on the Open Hardware Repository, at http://www.ohwr.org/documents/180, which can also be reached from the *Documents* tab of the *White Rabbit* project.

Plese note that only version 3.2 and 3.3 of both the motherboard and the backplane has been shipped commercially; you are interested in previous versions only if you are an early developer and have one of those in your hands.

A.1 DIP Switch HW version

Since v3.3, the backplane include a DIP switch configured by the manufacturer in order to define a specific SCB and backplane version. This setup is then read by the software in order to load the correct FPGA binaries and use the proper I/Os. Please be aware that if you upgrade your SCB from LX130T to LX240T but keep the same backplane you might need to change the DIP switch configuration. Check the code from `userspace/libswitchhw/i2c_io.c` code to know how to reconfigure the DIP switch for you upgraded device.

For example, the v3.3 backplane with v3.3 LX240T SCB must be configured as bellow:

```
+--------------+---+---+---+---+
| DIP position | 1 | 2 | 3 | 4 |
+==============+===+===+===+===+
| DIP value    | 1 | 1 | 1 | 0 |
+--------------+---+---+---+---+
```

Appendix B Older Hardware Releases

So, if you have an older PCB in your hands, your hardware is unsupported, but here are some notes that may be useful. The differences are minor, mainly in GPIO routing, but there is no complete list of changes readily available, unfortunately.

B.1 v3.2

This version should be fully supported with the latest firmware but few things haven been modified to enable backport compatibility.

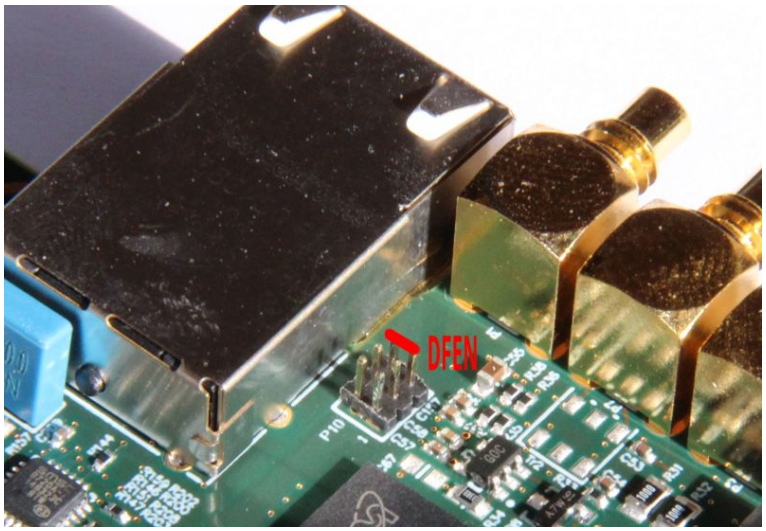
B.1.1 Flashing v3.2

The preferred way to communicate with the CPU internal ROM is through the **left** mini-USB port of the switch, also called managment USB port.

Once the USB cable plugged to your computer, the kernel should automatically load the proper device driver, and you are expected to see `/dev/ttyACM0` or equivalent in your system and it should be enumerated as below:

```
$ lsusb | grep Atmel
Bus 001 Device 025: ID 03eb:6124 Atmel Corp. at91sam SAMBA bootloader
```

If it is not the case, this mean that there is already some code in the *dataflash*, which the switch tries to boot. In order to disable the dataflash you need to open the switch box and fit a 1mm jumper[3] on the *DFEN* pin as shown in picture below to shortcut the *dataflash*.



With the jumper in place, you should reset the machine pressing the button near the 20-pin JTAG connector. When you see that the USB device has been enumerated, you should remove the jumper so the programming procedure can access the *dataflash* device.

After these steps you can follow the normal Section 3.2 [Flashing Procedure], page 6 to flash your device.

B.1.2 The Serial Ports in v3.2

In v3.2, the debug UART of the ARM is shared with the one from FPGA, and it can be switched by the FPGA. This multiplexed port is located on the front panel of the switch and corresponds

[3] On v3.0 & v3.1 this jumper does not exist. Refer to Section B.2.1 [Flashing v3.1/v3.0], page 18

to the **right** mini-USB *(Test)* port. By default, it is multiplexed on ARM UART until the FPGA toogle it sharing it with the FPGA UART.

Therefore, if you do not toogle, it should behave exactly like the ARM debug port in the v3.3.

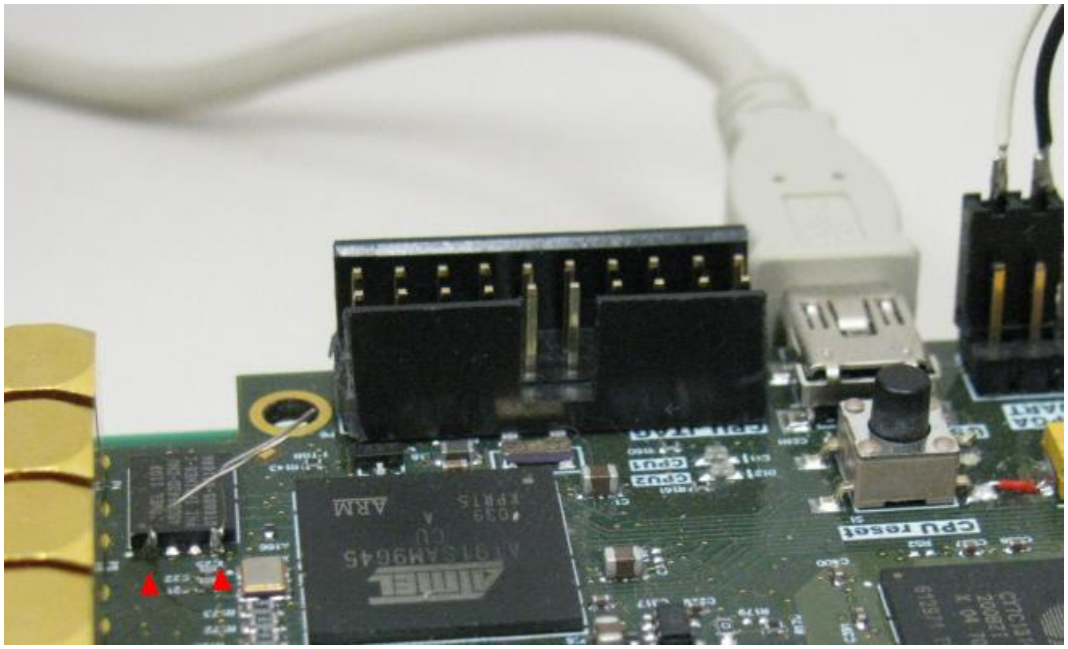
B.2 v3.1/v3.0

B.2.1 Flashing v3.1/v3.0

To flash any switch using the USB flasher, you need to force the ROM to run the boot protocol called SAMBA Monitor which mean that you must prevent the ARM from finding valid code in the *data-flash*.

In version 3.2 (see Section 3.1 [USB connections], page 5) there is a jumper to disable dataflash, however for version v3.0 & v3.1 it does not exist. Thus, you need to short pins 1 and 4 of the dataflash chip, so the `CS*` pin never goes low and the internal ROM won't be able to access your *at91boot* code.

I used two wires to be shorted together as needed. The next figure shows both the shorted pins (the *dataflash* is on the left and there are two arrowheads pointing to them) and the USB cable (on the right).



After shorting the pins you can press reset (the button near the USB connector). If things go well, the device is enumerated as shown; you must un-short the wires at this point or you will not be able to write the new information to *dataflash*.

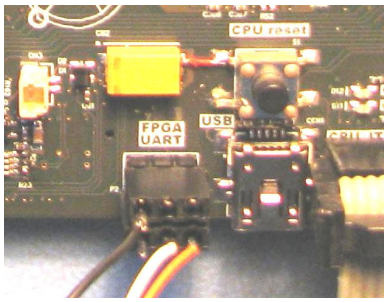
```
brezza% lsusb | grep Atmel
Bus 001 Device 025: ID 03eb:6124 Atmel Corp. at91sam SAMBA bootloader
```

The device should also appear as `/dev/ttyACM0` or equivalent, and the further flashing procedure is the same as in versione 3.2.

B.2.2 Serial Ports in 3.0/3.1

If you have a 6-port *mini-backplane*, you can connect the 6 pins of P2 to the similar connector on the backplane labeled as `Connect to MCH/P2`. The backplane hosts a CP2102 USB adapter and a mini-USB socket. Note that you may connect all 6 pins, but only TX and RX signals are needed. If you need more details for this setup, please write to the mailing list.

The port uses 2.5V signals, but a level converter for 3.3V usually works without issues or damages; the figure below shows the connection (black is GND, orange is RX and white is TX).



Appendix C Installing from Jtag

As an alternative to the serial flasher, you can take control of the system with a JTAG debugger. Please note that the *USB Flasher* is **really** the preferred technique, but in case it doesn't work for your, JTAG is the only way to communicate with the switch.

Each debugger has its own command language, so you will need to adapt to yours. What is shown here refers to the *peedi* & *sam-ice* tools. These notes are only aimed at low-level developers and leave a lot unsaid.

C.1 Using PEEDI

As a first step, you will need to ensure the JTAG clock is slow enough. The clock can be no faster than 1/6th of the CPU clock, so you need 3kHz at most (the G45 starts up with an internal oscillator, which has an unpredictable value between 20kHz and 40kHz). Then, I would verify that the internal SRAM is working; I do that with cool food and bad coffee instead of the usual smelly dead beef.

```
clock init
mem write 0x300000 0xc001f00d
mem write 0x300004 0xbadc0ffe
mem read  0x300000 2
==> 0x300000: 0xC001F00D 0xBADC0FFE
```

Now, you can load your *at91bootstrap* to the internal SRAM, retrieving it from the network or your host filesystem. Since no boot loader is there, you should place a breakpoint after *at91bootstrap* initialized SDRAM and the PLL. Finally you can load *barebox* and jump to it. Such step is better performed with the full JTAG clock, or it would take several dozen minutes.

```
mem load at91bootstrap.bin 0x300000
break add hard 0x300088
go
## wait for the breakpoint to happen
break del all
clock normal
mem load barebox.bin 0x73f00000
go
```

C.2 Using SAM-ICE

This section follows the same steps as in Section C.1 [Using PEEDI], page 19, but using the syntax of the SAM-ICE tool recommended by Atmel

```
./start
```

Checking SRAM

```
speed 2
w4 0x300000 0xc001f00d
w4 0x300004 0xcbadc0ffe
mem32 0x300000 2
```

Uploading at91bootstrap & barebox to DDR

```
speed 2
r
wreg "R15 (PC)" 300000
loadbin /tftpboot/at91bootstrap.bin 0x300000
SetBP 0x300088 H #Check 0x300088
g
speed a
loadbin /tftpboot/barebox.bin 0x73f00000
ClrBP 1
g
```

C.3 Installing the Boot Loader from JTAG

After tou managed to load and run *barebox.bin*, you will see the following messages on the serial port, at 115200,8N1. The first 4 lines are printed by *at91bootstrap*, the rest by *barebox*.

```
Start AT91Bootstrap...
DDR2 Config: 0x39 (NC=0xa, NR=0xd, CAS=0x3, ba_offset = 0x18)
DDR2 Config: 0x39 (NC=0xa, NR=0xd, CAS=0x3, ba_offset = 0x18)
Compiled by federico (Jul 31 2012  16:14:34)
git rev:

Begin to load image...
++++++++
Loading image done.


barebox 2012.05.0 (Aug  7 2012 - 13:44:23)

Board: CERN White Rabbit Switch V3
Clocks: CPU 400 MHz, master 133 MHz, main 12.000 MHz
registered netconsole as cs1
NAND device: Manufacturer ID: 0x2c, Chip ID: 0xbc (Micron NAND 512MiB 1,8V 16-bi
t)
Scanning device for bad blocks
GPIOs: PA4=1 (36), PC7=1 (103)
Malloc space: 0x73b00000 -> 0x73efffff (size  4 MB)
Stack space : 0x73af8000 -> 0x73b00000 (size 32 kB)
envfs: wrong magic on /dev/env0
no valid environment found on /dev/env0. Using default environment
running /env/bin/init...
Starting up barebox [wrs3] (MAC=02:0B:AD:C0:FF:EE)
starting menu in 5 seconds
```

When the boot loader is running, you can boot a kernel and use its own */dev/mtd* devices to write to the DataFlash and NAND memories.

According to the partition table you have in your kernel sources, you will see a different set of *mtd* files, but you can identify them by looking at `/proc/mtd`:

```
# cat /proc/mtd
dev:    size   erasesize  name
mtd0: 00800000 00020000 "Kernel"
mtd1: 08000000 00020000 "Filesystem"
mtd2: 00040000 00020000 "Barebox Environment"
mtd3: 14000000 00020000 "Available"
mtd4: 00840000 00000420 "spi0.0-AT45DB642x"
```

Here above, the DataFlash is */dev/mtd4*, whereas the former partitions refer to NAND memory. You should then write *at91boot* to offset 0 of the DataFlash and *barebox* to offset 0x8400 (33792):

```
cat at91bootstrap.bin > /dev/mtd4
dd bs=33792 seek=1 if=barebox.bin of=/dev/mtd4
```

Now you can detach the debugger, press reset and see *barebox* starting without the need for the JTAG any more. The following stes are the same as already described.

Appendix D Switching from HW-ECC to SW-ECC

After release 3.0 of this package we found that hardware ECC for NAND memory is bugged in the CPU we are using. Thus, we'll soon have a new release using software ECC, which however is not compatible, so a complete reinstall will be needed.

As a "quick and dirty" solution to the reliability problem, to be used before we develop and thoroughly test the new installation procedure, you can take and installed switch and turn it to software ECC support. The difference is in the ECC algorithms used by both *barebox* and the kernel. So both need to be recompiled.

To recompile the kernel, just undefine `CONFIG_MTD_NAND_ATMEL_ECC_HW` and define `CONFIG_MTD_NAND_ATMEL_ECC_SOFT` instead. To recompile barebox, similary, just adapt the configuration. The new configurations, for both *barebox* and the kernel, are included in this commit of the repository.

The following services and files are prerequisites to run this update:

- An installed switch, that runs the older *barebox*.
- A TFTP server, whence you can serve the kernel.
- Optionally, the current kernel, using hardware ECC for NAND.
- An NFS-Root installation (even a minimal one, with MTD tools).
- The new barebox, using software ECC
- The new kernel, using software ECC
- An archive of the filesystem (unchanged from release 3.0).

An archive with all the pieces you'll need for this upgrade (and maybe a little more than that) can be downloaded from the *files* section of the *White Rabbit* project on `ohwr.org`. (However, the archive doesn't include the filesystem image, which is big and didn't change from release 3.0). The direct link is:
`www.ohwr.org/attachments/download/1648/reflash-2012-10-09.tar.gz`

The manual steps for the upgrade, then, are the following ones:

1. Boot the switch using the TFTP script.
   If your switch has been installed and the *dataflash* is valid, you can boot it using the `boot from TFTP script` menu entry. See Section 4.2 [Using wrboot], page 10 for details. You don't need to access any NAND memory for this to work (so even if it got corrupted, you'll be able to boot).

2. Erase NAND.
   Before switching to a different ECC model, you should erase your NAND memory. All bits in erased blocks are set, so all bytes are 0xff with either ECC convention. All areas used by the system must be erased before switching to software ecc. This means `/dev/mtd0`, `/dev/mtd1` and `/dev/mtd2` (kernel, filesystem and barebox environment). This will forget your local barebox configuration (e.g., MAC address).

3. Boot again, with a new kernel
   Run again the TFTP script to boot from NFS-Root, but using a kernel that supports software ECC.
4. Write the kernel and filesystem to flash
   With this new kernel, you can write to NAND memory using software ECC. `/dev/mtd0` will host the new kernel (the same you booted) and `/dev/mtd1` will host the filesystem (unchanged from the previous installation).
5. Update barebox in data flash
   The final step is updating barebox, so it can read and boot the new kernel that is stored in flash with software ECC. Barebox must be stored at offset 0x8400 of the SPI memory.

The following example shows step 2 (erasing flash):

```
# flash_erase /dev/mtd0 0 0
Erasing 128 Kibyte  7e0000 -- 100 % complete

# flash_erase /dev/mtd1 0 0
Erasing 128 Kibyte  7fe0000 -- 100 % complete

# flash_erase /dev/mtd2 0 0
Erasing 128 Kibyte  20000 -- 100 % complete
```

The following example shows step 4 (writing the kernel and FS). You can't just "`cat zImage > /dev/mtd0`" because NAND memory can only be written in multiples of 512 bytes. So we'll add trailing unused data to the zImage before writing to flash, and the final error can be ignored. The final command (writing the filesystem) will take 50 seconds (uncompressing alone would take 18 seconds).

```
# dd bs=1k count=1 < /dev/zero > /tmp/1k
1+0 records in
1+0 records out

# cat zImage-wrs3-swecc /tmp/1k | dd obs=512 > /dev/mtd0
nand_do_write_ops: Attempt to write not page aligned data
dd: writing 'standard output': Invalid argument
2886+1 records in
2886+0 records out

# mount -t jffs2 /dev/mtdblock1 /mnt

# cd /mnt

# zcat /path/to/your/copy/of/wrs-image.tar.gz | tar xf -
```

The following example shows step 5 (updating barebox). The block size of the *dataflash* is 1056 bytes, and partial writes are supported (unless what happens with NAND flash) so no padding is needed. The command takes a few seconds to run:

```
# cat barebox.bin-swecc | dd bs=1056 seek=32 > /dev/mtd4
182+1 records in
182+1 records out
```

Hint: at any time, if in doubt about what version of *barebox* and the kernel you are running, you can check the date (`version` in *barebox* and `uname -a` in Linux). Hardware-ECC images are from August 2012 (official v3.0 release), while software-ECC images are from October 2012. If you recompiled and are in doubt about the kernel, you can *zgrep* for `ECC` in `/proc/config.gz`.

Appendix E Bugs and Troubleshooting

Even if we released the package as version 3.0 (being the first release for version 3 of the hardware), some details can be suboptimal, while some procedures may be tricky and need more explanation.

We are collecting all those issues in the *wiki* page of the project, to avoid frequent updates to this manual to just collect those details. So please visit www.ohwr.org/projects/wr-switch-sw/wiki/Bugs and www.ohwr.org/projects/wr-switch-sw/wiki/Troubleshooting if you have any problem with this package, but feel free to reach us on the mailing list if you don't find help there.