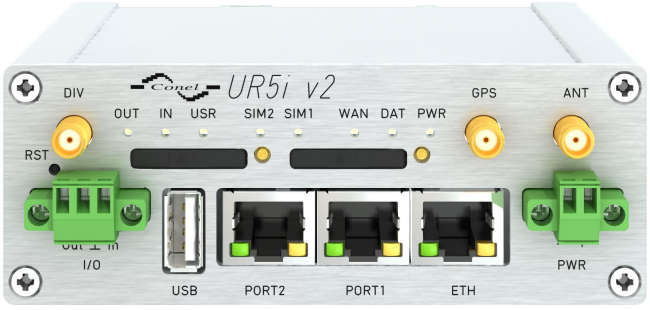
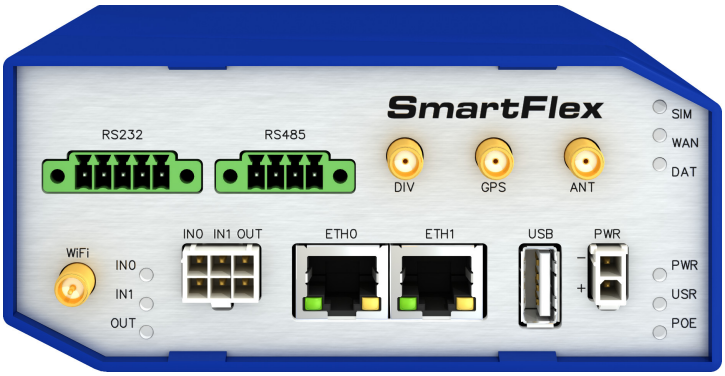
Programming of User Modules

APPLICATION NOTE





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Used symbols

Danger – Information regarding user safety or potential damage to the router.

Attention – Problems that can arise in specific situations.

Information, notice – Useful tips or information of special interest.

Example – example of function, command or script.

GPL license

Source codes under GPL license are available free of charge by sending an email to:

techSupport@advantech-bb.com

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1. Basic Information

User modules can be used for a special software applications in Advantech routers. This is to customize the router and to add new features. This guide describes programming of a user module so it can work in the Advantech routers. Directory structure of a user module, programming methods and technical information are explained to make it easy when programming your own user module.

The Linux OS is running in the Advantech routers. It is recommended to use the Linux OS for user modules development, but it is not required. You can use C, C++ or Python language to develop the user module. See the section 1.2 below for SDKs and cross compilers available. The general structure, scripts and general rules used in all user module development platforms are described in this guide.

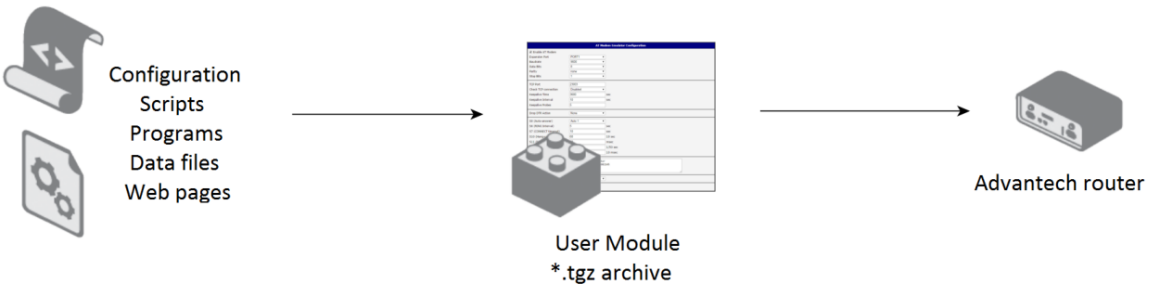

Figure 1: Programming of user modules for Advantech routers

1.1 Recommended Tools

- Cross compiler according to the platform used (see chapter 1.2 below).
- Optionally SDK for easier development and usage (see chapter 1.2 below).

1.2 SDKs and Cross Compiler Available

This chapter lists available SDKs and Cross Compilers that can be used for easier user modules development. The table below states the SDKs.

Language	Router Platform	SDK Download Link
C/C++	v2, v3	https://bitbucket.org/bbsmartworx/modulessdk
Python	v3	https://bitbucket.org/bbsmartworx/modulessdk

Table 1: SDKs available

Follow the *README* file in the SDK. It is recommended to download the SDK and look at the examples there when going through the following chapters.

Use the cross compiler mentioned in the table below to compile the SDK and an user module written in C/C++ language. Follow the *README* file instructions included in the compiler.

Language	Router Platform	Cross Compiler Download Link
C/C++	v2, v3	https://bitbucket.org/bbsmartworx/toolchains

Table 2: Cross compiler available

2. User Module Directory Structure

To upload the User Module into the Advantech router you need a **.tgz* archive with single directory in it (archive is packed using *tar* and then compressed using *gzip*) tool. The name of the **.tgz* archive and the directory in it has to be the same. This name can contain up to 24 characters of: 'a'-'z', 'A'-'Z', '0'-'9' and '_'. It is not recommended to use spaces in the names of subdirectories and files.

The <name> directory inside the archive can contain '/etc' subdirectory with the appropriate files in it – see the structure bellow and the following sections. There can be a '/www' subdirectory if there is a web interface of a user module, '/bin' subdirectory and any other subdirectories and files you need. All subdirectories and files are optional, you can employ what you need in your user module.

User module archive name convention:

<name>.<platform>.tgz, e.g. 'mymodule.v3.tgz'.

Command for creating user module archive:

```
tar -c --owner=0 --group=0 --mtime="2001-01-01 UTC" --exclude-vcs -C
\$MODNAME | gzip -n > \$MODNAME.\$PLATFORM.tgz
```

2.1 Internal archive structure

The schema below illustrates the internal structure of the user module archive.

<name>
|
|— **/etc/** Subdirectory with scripts, information and configuration files.
| |
| |— **defaults** Default configuration values.
| |— **depends** List of user modules this user module depends on.
| |— **init** Initial script.
| |— **install** Script will run during installation process.
| |— **ip-up** Script executed when WAN connection is established (for IPv4).
| |— **ip6-up** Script executed when WAN connection is established (for IPv6).
| |— **ip-down** Script executed when WAN connection is lost (for IPv4).
| |— **ip6-down** Script executed when WAN connection is lost (for IPv6).
| |— **name** Human readable name used in the web interface.
| |— **requires** The lowest compatible version of router's firmware.
| |— **settings** Actual configuration file. Not in the **.tgz* archive.
| |— **uninstall** Script will run during uninstallation process.
| \— **version** Version of the user module showed in the web interface.
|
|— **/bin/** Subdirectory with your auxiliary files, daemons or **.cgi* scripts.
|
\— **/www/** Subdirectory with web interface files.

File type legend:

Information files - see chapter 2.2
Configuration files - see chapter 2.3
Script files - see chapter 2.4

2.2 Information Files in /etc Directory

depends

There is a list of dependencies (all user modules the user module depends on) in this file. The format of the file is one user module per line and the name of the user module has to be same as the name of user module's directory <name> in the **.tgz* archive.

File content example:

```
Python
otherModuleName
```

name

This file contains the long human readable user module name. It will be shown in the web interface of the router. Following characters are recommended to be used for user module name: 'a'-'z', 'A'-'Z', '0'-'9' and ' '. If there is no 'name' file, the directory <name> is used instead.

File content example:

```
My User Module
```

requires

There is required minimal version of the router's firmware in this file. It has three numbers format of the router firmware versioning – MAJOR.MINOR.PATCH.

File content example:

```
5.2.0
```

version

The file with module version information. It will be shown in the web interface. The recommended format is the semantic versioning MAJOR.MINOR.PATCH and a date in YYYY-MM-DD format as shown below. If this file is missing, the version of the user module will not be shown in the web interface of the router.

File content example:

```
1.0.0 (2015-07-15)
```

2.3 Configuration Files in /etc Directory

defaults

The default configuration parameters have to be saved in this file. These parameters are used during installation and when RST button on the router is pressed (back to factory defaults reset). The content of this file should be copied by 'init' script (see the next section) into the 'settings' file on install (see below) to enable the backup of configuration of the user module. You do not need this file if the user module has no configuration. Variables have to be defined this way:

`MOD_<name>_<variable name>=<value>,`

where `MOD` stays for 'user module' so it is recognizable when together with rest of the configuration parameters of the router, `<name>` is the name of the user module (same as the the directory and archive name) and `variable name` is the desired parameter name.

File content example:

```
MOD\_MYMODULE\_ENABLED=1\newline
MOD\_MYMODULE\_PARAM1=0\newline
MOD\_MYMODULE\_PARAM2=5\newline
MOD\_MYMODULE\_PARAM3=20
```

settings

This file should not be in the **.tgz* archive of the user module. It should be created during installation by 'init' script. There should be a line copying the 'defaults' file into the 'settings' file in the 'init' script when installing the user module. See 'init' script in the chapter 2.4.

The 'settings' file allows to make the backup of the configuration. It can be backed up together with router's configuration and it can remain on the user module update.

When backing up the router's configuration, the 'settings' file is added to the router's configuration file and all the parameters are downloaded together in a single **.cfg* file. When updating the user module, the 'settings' file is backed up and the newer version of the user module looks for the 'settings' file first. It goes back to the 'defaults' file only if there are some new parameters.

2.4 Scripts in /etc Directory

init

This is an initialization script. It is called with different parameters in different situations (start of the router, add, update, delete of the user module, see the chapter 3.1). It can be called

manually with the desired parameter, too. If there is no 'init' script, nothing happens and nothing is done on the user module initialization in the given situations. These are the parameters of the script:

- **start** – The 'init' with the 'start' parameter is called automatically when starting the router or after the installation of the user module.
- **stop** – The 'init' with the 'stop' parameter is called automatically before update or uninstalling the module.
- **restart** – The 'init' with the 'restart' parameter is not called automatically – it can be called manually only.
- **status** – The 'init' with the 'status' parameter is not called automatically – it can be called manually only. It is the status whether the user module is running or not.
- **defaults** – The 'init' with the 'defaults' parameter is called automatically after installing the module or when the RST button is pressed. This is to copy the contents of 'defaults' file into the working configuration – 'settings' file.

An example of an 'init' script is shown below. There are just strings returned to inform what is going on in the example. Notice the copy 'cp' at the 'defaults' parameter to enable the backup of configuration. You can find this source code in the 'example1' of our *SDK* documentation.

```
#!/bin/sh

MODNAME=mymodule

case "$1" in
  start)
    echo "Starting module $MODNAME: done"
    exit 0
    ;;
  stop)
    echo "Stopping module $MODNAME: done"
    exit 0
    ;;
  restart)
    $0 stop
    $0 start
    ;;
  status)
    echo "Module $MODNAME is running"
    exit 0
    ;;
  defaults)
    cd /opt/$MODNAME/etc && cp defaults settings
    ;;
  *)
    echo "Usage: $0 {start|stop|restart|status|defaults}"
    exit 1
esac
```

install

This is an installation script. It is executed just after the uploading of the user module into the router (files copied). See the next chapter 3.1 for more details on the order of scripts executed during the installation process.

uninstall

This script is executed during the uninstallation process of the user module. It is called just after stopping the user module ('init stop') and just before deleting the files of the user module. See the next chapter 3.1 for more details on the order of scripts executed during the uninstallation process.

ip-up

This script is executed when the WAN connection using IPv4 address is established. It works the same way as Up/Down Script in the router's web interface, but just for the particular user module. This script is called with following parameters:

```
/opt/mymodule/etc/ip-up <ip-address-of-WAN-interface> <WAN-interface>
```

Below is the example of the script execution for internet connection established via Mobile WAN with IPv4 address 10.40.28.64.

```
/opt/mymodule/etc/ip-up 10.40.28.64 ppp0
```

ip6-up

This script is executed when the WAN connection using IPv6 address is established. This script is called with following parameters:

```
/opt/mymodule/etc/ip6-up <ip6-address-of-WAN-interface> <WAN-interface>
```

Below is the example of the script execution for internet connection established via Mobile WAN with IPv6 address fc00::a40:37.

```
/opt/mymodule/etc/ip6-up fc00::a40:37 ppp0
```

ip-down

This script is executed when the WAN connection using IPv4 address is lost. It is called with the same parameters as the previous 'ip-up' script:

```
/opt/mymodule/etc/ip-down <ip-address-of-WAN-interface> <WAN-interface>
```

Below is the example of the script execution for internet connection lost on Mobile WAN with IPv4 address 10.40.28.64.

```
/opt/mymodule/etc/ip-down 10.40.28.64 ppp0
```

ip6-down

This script is executed when the WAN connection using IPv6 address is lost. It is called with the same parameters as the previous 'ip6-up' script:

```
/opt/mymodule/etc/ip6-down <ip6-address-of-WAN-interface> <WAN-interface>
```

Below is the example of the script execution for internet connection lost on Mobile WAN with IPv6 address fc00::a40:37.

```
/opt/mymodule/etc/ip6-down fc00::a40:37 ppp0
```

2.5 Web Interface Files in /www Directory

This directory contains any .html, .cgi or other files of the web interface of the user module. If there is file index.html, index.cgi etc., it is accessible in the router's web interface in the *Customization* section, *User Modules*. If there is no 'www' folder, there is no link to the web interface of the user module and if there is no 'index' file, there is no web interface to show up for the user module. The directory is linked to this URL address of the router:

/opt/mymodule/www ⟶ http(s)://<router ip address>/module/mymodule

Regarding security you have 2 options – secured with the router's usernames and passwords or unsecured:

1. **Secured**: create a '.htpasswd' file in this 'www' directory with a symbolic link to the file '/etc/htpasswd' where the router's usernames and encrypted passwords are stored. This is the recommended option. Example of the '.htpasswd' file:

```
ln -s /etc/htpasswd .htpasswd
```

2. **Unsecured**: there is no '.htpasswd' file and anyone can access the web interface and files of the user module. It is strongly recommended not to use this option.

3. Programming Information

Useful information for programming of user modules can be found in this chapter. There is handling of user module explained – adding, updating and deleting the user module – what scripts are called in what order. Access to the hardware interfaces of the router is described. Important note on firewall integration, information on libraries and dependency, and older firmware compatibility are written out.

You can use lot of programs and commands already included in the router's operating system. See the ***Commands and Scripts for v2 and v3 Routers*** Application Note for the documentation or press TAB key twice when connected to the console of the router (via SSH or Telnet). The list of possible commands will show up. You can write `<command> --help` for more information on that command.

3.1 Actions – Add, Update, Delete and Scripts Call Order

Generally you can put anything you need in the shell scripts. The order of scripts called on different actions is described below. If you want to see the log of scripts called (in the web interface System Log, for debug reason etc.), add this line at the beginning of each script. Here `$0` is a script itself and `$@` are its parameters.

```
/usr/bin/logger -t mymodule "DEBUG: \$0 \$@"
```

3.1.1 Add User Module – Install

Installation of the user module is done by uploading the user module into the router (*Customization* section). The **.tgz* archive is extracted and the user module directory is copied into the `/opt` directory of the router's file system. So the path to the user module files is `/opt/mymodule`. After files are copied the scripts are called in the order below and with these parameters:

1. *Add or Update* button pressed – **.tgz* archive uploaded, extracted and copied into the `/opt` directory.
2. `/opt/mymodule/etc/install` – script executed.
3. `/opt/mymodule/etc/init defaults` – script executed.
4. `/opt/mymodule/etc/init start` – script executed.

3.1.2 Update User Module

Update is done the same way as adding the user module, but as the user module has the same name, the previous running version is stopped first and the settings is backed up, too:

1. *Add or Update* button pressed.
2. `/opt/mymodule/etc/init stop` – script is executed if the name of the user module is the same. The configuration file 'settings' is backed up. Then the old user module files are deleted and the new **.tgz* archive is uploaded, extracted and copied into the `/opt` directory.
3. `/opt/mymodule/etc/install` – script executed.
4. `/opt/mymodule/etc/init defaults` – script executed. Now when the 'settings' file is created from 'defaults', it is overwritten by 'settings' file from backup. If there are any new parameters, they are taken from 'defaults'.
5. `/opt/mymodule/etc/init start` – script executed.

3.1.3 Delete User Module – Uninstall

Deleting of the user module is done by pressing the *Delete* button next to the user module you want to delete. These scripts are executed before deleting the files of the module:

1. *Delete* button pressed at the user module.
2. `/opt/mymodule/etc/init stop` – script executed.
3. `/opt/mymodule/etc/uninstall` – script executed.
4. The whole user module directory is removed from `/opt` directory of the router.

3.2 Hardware Interfaces

The access to the hardware interfaces is described in this chapter. You can use serial interface, all the network interfaces, binary inputs/outputs, user LED, MRAM, storage space etc. in your user module.

See the block diagram for v3 routers on the figure 2 below. v2 routers are similar, but have different memory sizes, different CPU and the PORT boards are not interconnected the same way. Actual differences are described in the text below.

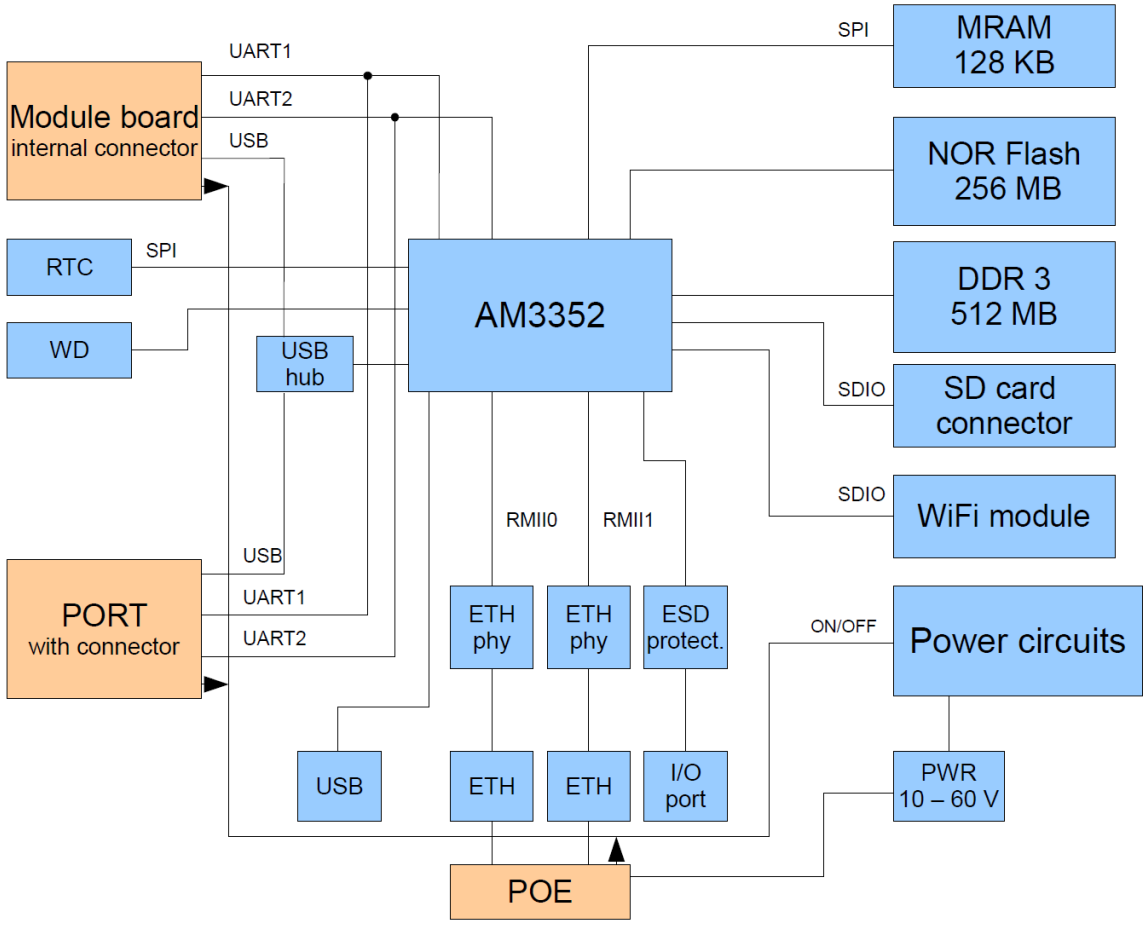

Figure 2: Block diagram of v3 routers

3.2.1 Serial Line Interface

This applies to the routers with serial line interface only. Access the serial line as a file since the Linux OS is running in the router. The path to the serial line file in the router's file system:

`/dev/ttyS0` or `/dev/ttyS1`

It differs based on the v2 or v3 platform and the PORT used:

v3 platform It is usually `/dev/ttyS0` for v3 routers if the version of the router (the PORT used) has only one serial line interface and if the connector of the serial line interface is on the left side of the router's front panel. If you have a version with two serial interfaces (e.g. RS232 and RS485), both `ttyS0` and `ttyS1` are used. Generally both UART1 and UART2 are connected to both additional boards as you can see from the Fig. 2.

v2 platform It is clear in v2 routers:
Serial line interface on PORT1: `/dev/ttyS0`
Serial line interface on PORT2: `/dev/ttyS1`

See the figure below – the additional board connectors only one UART connected.

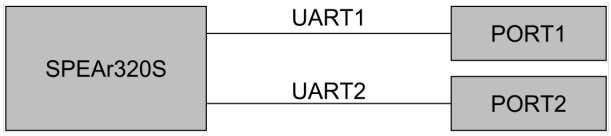

Figure 3: Block diagram of v2 router's CPU and UARTs connected to PORTs

Read the file to get the serial line input and write to this file to send data via serial line. Handle the files using appropriate locks: A user module can be started as root, which means it can have full access to the system. Access to serial lines should be cared using file check and creation (locks) in directory /var/lock. A lock file has to be created in /var/lock before opening the serial line. The lock file name contains of 'LCK..' string and device name, e.g. for `/dev/ttyS0` the lock file will be `LCK..ttyS0`. Save the process identifier (PID) of the process running on an open device into this lock file. The PID format is 11 characters long – fill the spaces before the number and add end of the line. (E.g. for process 5634: space, space, space, space, space, space, 5, 6, 3, 4, end of line). The lock file has to be deleted when the work with the interface is finished. There is a function to handle this in our *SDK* library.

3.2.2 Ethernet and Network Interfaces

You can access Ethernet and other network interfaces as a standard Linux network interfaces. Use `ifconfig` command to see and configure the network interfaces in the router. Detailed description of the command can be found in the *Commands and Scripts for v2 and v3 Routers*, Application Note.

These are some important physical interfaces of the router:

`eth0` ETH, PORT1 (XC-SW), PORT2 (XC-ETH, XC-SW) connectors on v2 routers.
ETH0 connector on v3 routers.

`eth1` PORT1 (XC-ETH) connector on v2 routers.
ETH1 connector on v3 routers.

`eth2` ETH2 switched connectors on SWITCH versions of v3 routers only.

`pppX/usbX` Mobile WAN connection (cellular module board connection). It is typically `ppp0` or `usb0`, depending on the model of the router. `usb0` is the first module on the routers with two modules, `usb1` is the second. `pppX` interface numbering varies.

`wlan0` WiFi connection on WiFi version of the router.

There can be additional network interfaces in the router, depending on the configuration and tunnels settings.

3.2.3 I/O Interface

You can use the `io` program to control binary outputs and to read binary inputs. It supports reading state of binary outputs and setting state of counters. See the User's Manual for your router for details on binary inputs/outputs. **Note:** Binary inputs/outputs have inverse logic.

Synopsis: `io [get <pin>] | [set <pin> <value>]`

Option	Description
`get`	Get the state of input
`set`	Set the state of output

Table 3: io options

Examples:

`io set out0 1`	Set the state of binary output OUT0 to 1.
`io get bin0`	Get the state of digital input BIN0.
`io get an1`	Get the state of analog input AN1 on expansion port XC-CNT.
`io get cnt1`	Get the state of counter input CNT1 on expansion port XC-CNT.

3.2.4 User LED Interface

You can control the USR LED on the front panel of the router via the program `led`.

Synopsis: `led [on | off]`

Option	Description
`on`	User LED is on
`off`	User LED is off

Table 4: led options

Examples:

`led on`	Turn on USR LED.
`led off`	Turn off USR LED.

3.2.5 MRAM Access and Size

You can use and access the MRAM memory and its advantages. It is accessible in the `/var/data` directory of the router's file system. The size of the MRAM is 128 kB, but it is recommended to use maximum of 64 kB by a user module, because the router's operating system uses this memory, too. The file system of MRAM is JFFS2. You can fit there up to twice as big data if compression used and if the data can be compressed well. It is recommended to create the user module <name> subdirectory in `/var/data`. The /var/data/<name> subdirectory is deleted automatically on user module removal. Clean up of other files or subdirectories is up to the author of the user module.

3.2.6 RAM Size

There is 64 MB of RAM on v2 routers and 512 MB of RAM on v3 routers. You can use the standard way of dynamic memory allocation (e.g. `malloc` function). Be careful regarding the memory usage – do not deplete all the memory for your user module.

3.2.7 Storage Access – USB Flash and SD Card

Connecting the USB device or SD card works the standard way as in Linux OS. When you connect a USB Flash stick to the router, you can see it in the `/dev` directory. You can use see the details on detected devices using `dmesg` command.

- **USB Flash stick** will typically show up as `/dev/sda1`. You can mount it with the `mount` command.
  (E.g. `mount -t vfat /dev/sda1 /mnt`).
- Some USB to serial converters are supported. These will show up as `ttyUSB0`, `ttyUSB1` etc. devices.
- **SD Card** inserted in the SD card reader will on the router will show up as `/dev/mmcblk0p1`. You can mount it the standard way. (E.g. `mount -t vfat /dev/mmcblk0p1 /mnt`.)

3.2.8 I/O Control – Lower Hardware API

You can use even lower hardware API – Unix I/O control (ioctl). This can have better performance in some cases, but it can be harder to implement, too. Here are GPIO driver iocontrol command codes in the table below with the Shell program alternative or close feature if available.

Variable – Action	Code	Input	Output	Shell
UM_GPIO_GET_MO1_SIM **Get index of SIM card in the first cellular module**	0x80004202U	0	0 or 1	—
UM_GPIO_SET_LED_USR **Set state of LED USR**	0x40004203U	0 or 1	0	`led`
UM_GPIO_SET_OUT0 **Set state of output OUT0**	0x40004206U	0 or 1	0	`io`
UM_GPIO_GET_OUT0 **Get state of output OUT0**	0x80004206U	0	0 or 1	`io`
UM_GPIO_GET_BIN0 **Get state of input BIN0**	0x80004207U	0	0 or 1	`io`
UM_GPIO_GET_PORT1_TYPE **Get type of expansion port 1**	0x80004209U	0	Code in Table 6	`status ports`
UM_GPIO_GET_PORT1_OVRL **Get information on port 1 MBUS overload**	0x8000420AU	0	0 or 1	—

To be continued on the next page

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Variable – Action	Code	Input	Output	Shell
UM_GPIO_GET_PORT2_TYPE **Get type of expansion port 2**	0x8000420BU	0	Code in Table 6	`status ports`
UM_GPIO_GET_PORT2_OVRL **Get information on port 2 MBUS overload**	0x8000420CU	0	0 or 1	—
UM_GPIO_GET_MO1_TYPE **Get type of the first module board**	0x8000420EU	0	Code in Table 7	—
UM_GPIO_GET_TEMPERATURE **Get internal temperature**	0x80004211U	0	Integer number in Kelvin	`status sys`
UM_GPIO_GET_VOLTAGE **Get supply voltage**	0x80004212U	0	Integer number in milli-volts	`status sys`
UM_GPIO_SET_PORT1_SD **Shutdown expansion port 1**	0x40004214U	0 or 1	0	—
UM_GPIO_GET_PORT1_SD **Get shutdown of expansion port 1**	0x80004214U	0	0 or 1	—
UM_GPIO_SET_PORT2_SD **Shutdown expansion port 1**	0x40004215U	0 or 1	0	—
UM_GPIO_GET_PORT2_SD **Get shutdown of expansion port 2**	0x80004215U	0	0 or 1	—
UM_GPIO_GET_MO2_SIM **Get index of SIM card in the second module**	0x80004216U	0	0 or 1	—
UM_GPIO_GET_MO2_TYPE **Get type of the second module board**	0x80004219U	0	Code in Table 7	—
UM_GPIO_GET_MOD_IDX **Get index of selected module**	0x8000421AU	0	0 or 1	—
UM_GPIO_GET_BIN1 **Get state of input BIN1**	0x8000421BU	0	0 or 1	`io`

Table 5: GPIO driver iocontrol command codes

On GET codes – you get typically boolean output where 1 means "yes" and 0 means "no", except for binary inputs/outputs – these have reversed logic. If an error occurs, -1 value is returned. The codes and variables can be found in our SDK library, The variables should be named as mentioned in the table above for proper work. There are board types on output codes in the tables below:

Output Code	Variable – Port Type
0x00	UM_GPIO_PORT_TYPE_EMPTY
0x02	UM_GPIO_PORT_TYPE_RS232
0x03	UM_GPIO_PORT_TYPE_RS485
0x04	UM_GPIO_PORT_TYPE_MBUS
0x05	UM_GPIO_PORT_TYPE_CNT
0x08	UM_GPIO_PORT_TYPE_ETH
0x0A	UM_GPIO_PORT_TYPE_WMBUS
0x0B	UM_GPIO_PORT_TYPE_RS422
0x0F	UM_GPIO_PORT_TYPE_NONE
0x11	UM_GPIO_PORT_TYPE_WIFI
0x12	UM_GPIO_PORT_TYPE_SDCARD
0x13	UM_GPIO_PORT_TYPE_DUST
0x20	UM_GPIO_PORT_TYPE_SWITCH

Table 6: GPIO port type codes

Output Code	Variable – Module Board Type
0x00	UM_GPIO_MODULE_TYPE_EES3
0x01	UM_GPIO_MODULE_TYPE_EU3
0x02	UM_GPIO_MODULE_TYPE_MCXXXX_VWM10
0x03	UM_GPIO_MODULE_TYPE_PHS8
0x04	UM_GPIO_MODULE_TYPE_MCXXXX
0x05	UM_GPIO_MODULE_TYPE_VWM10
0x06	UM_GPIO_MODULE_TYPE_GOBI3K
0x0A	UM_GPIO_MODULE_TYPE_MCXXXX_MCXXXX
0x0F	UM_GPIO_MODULE_TYPE_NONE

Table 7: GPIO cellular module board type codes

3.3 Firewall Integration

If you want to use a TCP or UDP server in your user module (or generally any program listening on TCP or UDP port), read this chapter carefully – there are information on how your user module should handle the firewall in the router.

There is `iptables` program integrated in the router. It is used for Firewall and NAT rules processing.

There is the *Send all remaining incoming packets to default server* item (see figure 4) in the NAT configuration of the router (separately for IPv4 and IPv6). If enabled (and the IP address is filled in), it will apply the Firewall and NAT rules first and the rest of incoming packets are sent to the configured default server. It ignores the TCP/UDP port your user module is listening on. Therefore the user module should add the `iptables` rules for itself during the installation process and remove them on its uninstallation. The best way to do it is in the 'init' script.

Figure 4: The default server in the NAT configuration (for IPv4)

The example of the 'init' script adjusting the `iptables` rules is shown below. There are `add_chain()` and `del_chain()` functions and then the usual 'init' script continues with the `case` switch. Note that the script below is shortened, the rest of the parameters is skipped in this example.

The `iptables` rules are added in the `add_chain()` function so the Firewall can accept it and so the NAT will not send it to the default server. The `add_chain()` function is then called by the 'init start'. It has parameters e.g. `mod_mymodule tcp 1000` as you can see from the example below. Here 1000 is the TCP port number defined in the 'settings' file of the user module. Now when the packet comes to TCP port 1000, it is accepted even if there is default server set in NAT configuration of the router.

The `del_chain()` function is called on 'init stop' likewise. It's parameter is `mod_mymodule` as you can see in the example below. This is to remove the `iptables` rules on the user module removal (or restart, or manually on 'init stop').

```
MODNAME=mymodule
MODEXEC=mymoduled

add_chain() {
  /sbin/iptables -N $1 || return
  /sbin/iptables -A $1 -p $2 --dport $3 -j ACCEPT
  /sbin/iptables -A in_mod -j $1
  /sbin/iptables -t nat -N $1
  /sbin/iptables -t nat -A $1 -p $2 --dport $3 -j ACCEPT
  /sbin/iptables -t nat -A pre_mod -j $1
  if [ -f /sbin/ip6tables ]; then
    /sbin/ip6tables -N $1 || return
    /sbin/ip6tables -A $1 -p $2 --dport $3 -j ACCEPT
    /sbin/ip6tables -A in_mod -j $1
    /sbin/ip6tables -t nat -N $1
    /sbin/ip6tables -t nat -A $1 -p $2 --dport $3 -j ACCEPT
    /sbin/ip6tables -t nat -A pre_mod -j $1
  fi
}

del_chain() {
  /sbin/iptables -D in_mod -j $1
  /sbin/iptables -F $1
  /sbin/iptables -X $1
  /sbin/iptables -t nat -D pre_mod -j $1
  /sbin/iptables -t nat -F $1
  /sbin/iptables -t nat -X $1
  if [ -f /sbin/ip6tables ]; then
    /sbin/ip6tables -D in_mod -j $1
    /sbin/ip6tables -F $1
    /sbin/ip6tables -X $1
    /sbin/ip6tables -t nat -D pre_mod -j $1
    /sbin/ip6tables -t nat -F $1
    /sbin/ip6tables -t nat -X $1
  fi
}
```

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```
case "$1" in
  start)
    echo -n "Starting module $MODNAME: "
    . /opt/$MODNAME/etc/settings
    [ "$MOD_EXAMPLE5_ENABLED" != "1" ] && echo "skipped" && exit 0
    add_chain mod_$MODNAME tcp $MOD_MYMODULE_PORT 2> /dev/null
    /opt/$MODNAME/bin/$MODEXEC &
    RETVAL=$?
    [ $RETVAL = 0 ] && echo "done" || echo "failed"
    exit $RETVAL
    ;;
  stop)
    echo -n "Stopping module $MODNAME: "
    killall $MODEXEC 2> /dev/null
    del_chain mod_$MODNAME 2> /dev/null
    RETVAL=$?
    [ $RETVAL = 0 ] && echo "done" || echo "failed"
    exit $RETVAL
    ;;
  *)
    echo "Usage: $0 {start|stop|restart|status|defaults}"
    exit 1
esac
```

There are `in_mod` and `pre_mod` parameters in `iptables` rules in functions `add_chain()` and `del_chain()`. Here is the iptables structure used in the router so you know when `in_mod` and `pre_mod` rules are applied. Note that there is many more rules nested in the structure, but only the ones applicable for user modules are shown in the structure below:

- `mangle PREROUTING`
- `nat PREROUTING`
  - `pre` (WAN interfaces only)
    - `pre_mod` - ACCEPT rules for installed user modules
      - `mod_...`
      - `mod_...`
      - `mod_...`
- `nat POSTROUTING`
- `filter INPUT`
  - `in`

- `in_mod` - ACCEPT rules for installed user modules
  - `mod_...`
  - `mod_...`
  - `mod_...`

- `filter FORWARD`

3.4 Libraries and Dependency

To maintain the proper work of the user module after the router's firmware update, observe these two recommendations for libraries and dependencies:

- Do not link the libraries dynamically. Use the static link with your user module only.
- Do not use libraries from the file system of the router, except for *glibc* library.

The reason is that the libraries in the router's firmware can change and vary in the updated firmware versions. The user module should be independent on the libraries of the router's firmware so it can work properly after the firmware update.

If you write your user module in the C language – you can use *glibc* library from the router's file system (located in '/lib' directory in the router). Only use the functions up to the 2.0.6 version from *glibc* library. This is to maintain the compatibility within all firmware versions since there is *glibc 2.0.6* library in all versions of the router's firmware.

3.5 Older Firmware Compatibility

User modules are supported since firmware 2.1.2 in the router. If you want to keep your user module compatible with all versions of the firmware, use only the functions from *glibc 2.0.6* library or lower. If you do not use *glibc* functions at all, there will be no compatibility issues with the user module.

If you are writing your user module for v2 routers in C++ and if you want your user module to be compatible with firmware lower than 5.1.0, then you have to link the *libstdc++* library statically with your user module. The *libstdc++* library is a part of firmware since 5.1.0 and higher.

4. CPU and Toolchains

4.1 CPU and Memory

There are CPU and memory parameters for both platforms of router (v2 and v3) in the table below.

Parameter	v2 Routers	v3 Routers
CPU	SPEAr320S	AM3352
Architecture	arm v5	arm v7
Core	ARM926EJ-S	ARM® Cortex®-A8
CPU power	360 DMIPS	2000 DMIPS
RAM	64 MB	512 MB
M-RAM (/var/data)	128 kB	128 kB
Flash memory	16 MB	256 MB
/opt size	2 MB	128 MB

Table 8: CPU and memory parameters

4.2 Crosscompilation – Toolchains and Flags

This is applicable if you are crosscompiling the user module written in C or C++. It is recommended to download and use toolchains offered in chapter 1.2.

You can use other crosscompiler, too. Use these flags for successful crosscompilation, based on the router's platform:

v2 routers Flags for crosscompilation for v2 routers:

```
-march = armv5te
-mtune = arm926ej-s
-mfloat-abi = soft
```

v3 routers Flags for crosscompilation for v3 routers:

```
-march = armv7-a
-mtune = cortex-a8
-mfpu = vfpv3
-mfloat-abi = softfp
```

5. Constraints

- Use only 64 kB of MRAM memory in `/var/data` for smooth run of user module and the router's firmware. See chapter 3.2.5 for more details.
- The space in '/opt' directory where user modules are stored is limited. There is:
  - 2 MB in '/opt' directory in v2 routers,
  - 128 MB in '/opt' directory in v3 routers.

  The file system of '/opt' directory is JFFS2 so you can load in there more data if compressed (the amount of data depends of data itself – how well it can be compressed). The '/opt' directory is not erased on the update of the router's firmware.

6. Recommended Literature

[1] Advantech B+B SmartWorx: **v2 Routers Configuration Manual** (MAN-0021-EN)

[2] Advantech B+B SmartWorx: **SmartFlex Configuration Manual** (MAN-0023-EN)

[3] Advantech B+B SmartWorx: **SmartMotion Configuration Manual** (MAN-0024-EN)

[4] Advantech B+B SmartWorx: **SmartStart Configuration Manual** (MAN-0022-EN)

[5] Advantech B+B SmartWorx: **ICR-3200 Configuration Manual** (MAN-0042-EN)

[6] Advantech B+B SmartWorx: **Commands and Scripts for v2 and v3 Routers** – Application Note (APP-0002-EN)

Product related documents can be obtained on *Engineering Portal* at https://ep.advantech-bb.cz/ address.