Application Note: JN-AN-1194a

ZigBee IoT Gateway - User Guide

The NXP ZigBee IoT Gateway provides a means of controlling ZigBee devices using a smart device such as smartphone, tablet or PC, either over a local network or over the Internet. It is initially targeted at ZigBee Light Link and Home Automation light bulbs, although it will be possible in later releases to support other devices, for example, Home Automation door locks and other Smart Home devices.

This guide provides information to allow users to set up and operate the ZigBee IoT Gateway software using the hardware found in a JN516x-EK001 Evaluation Kit and the LPC3240-based IoT Gateway Reference Design (JN-RD-6040).

1 Application Note Overview

The purpose of this Application Note is to show how a ZigBee Gateway can be realised that will allow control of NXP ZigBee devices, along with devices from other manufacturers, through a Gateway consisting of either a commercially-available hardware platform (Linksys WRT160NL) or a custom design containing an NXP host processor and NXP 802.15.4 silicon (LPC3240-based IoT Gateway Reference Design JN-RD-6040).

This guide is intended to show how to set up and use the Gateway in a simple demonstration network of ZigBee Light Link (ZLL) and ZigBee Home Automation (ZHA) devices in order to familiarise users with the functions available in the Gateway firmware. Companion documents included in the Application Note discuss the structure of Gateway firmware and the various components into which the firmware is partitioned. The demonstration described in this guide uses the hardware found in the JN516x-EK001 Evaluation Kit. The firmware used in the Gateway is supplied as source code to allow the user to make changes and customise the various components to their needs. Firmware for the devices to be controlled by the Gateway can be built from the JN-AN-1189 ZigBee Home Automation Demonstration Application Note and the JN-AN-1171 ZigBee Light Link Solution Application Note, but for convenience, binaries for a ZLL Color Light and ZHA Dimmable Light which work on the evaluation kit boards are supplied in this package.

The software in the ZigBee IoT Gateway host processor is a port of OpenWRT, which is itself based on Linux; OpenWRT has been ported to the Linksys WRT160NL router and also the NXP IoT Gateway Reference Design (JN-RD-6040). The architecture of the hardware consists of a host processor running the OpenWRT software together with a JN5168 device used to communicate with devices in a ZigBee network. The host processor and JN5168 communicate through a serial connection.

The application interface uses the same control principles for the ZigBee devices as are used in the JIP layer of the JenNet-IP protocol stack. In the JIP application layer, properties of an application or device are collected together into logical groups known as MIBs. Normally MIBs are held locally on the device whose properties they describe, and their contents are accessible directly from remote devices such as tablets or smartphones over the internet. To allow ZigBee devices to be controlled through a JIP interface, a mapping was carried out between the functionality available on ZigBee devices, such as ZLL and ZHA Lights, and the corresponding JenNet-IP device. The MIBs in this case are resident on the host processor of the IoT Gateway rather than on the ZigBee device. Thus, the control interface provided by the Host to the internet or Wi-Fi network uses the MIB concept used

within JIP. For more detail, see the “ZigBee IoT Gateway – Host” document included in the application note package.

The Host processor presents two interfaces:

- a web server which provides webpages displaying the contents of the various MIBs present, mapped to the devices in the ZigBee network,
- a command interface which allows JIP commands generated from an application to manipulate the MIB contents directly.

The use of a common application layer means that the same application can be used to control both ZigBee and JenNet-IP devices through the same gateway, provided that there is a 802.15.4 node for each network. This approach greatly simplifies mixing ZigBee and JenNet-IP networks in the same location.

The use of the MIB structure, as defined for JenNet-IP devices, is a reasonably close match for the corresponding ZigBee device; monochrome dimmable lights in either system need to be switched on and off and set to a particular brightness, and colour lights need to have their colour altered. However, in some instances there are variables present in a MIB which do not have a corresponding function in the ZigBee device, and correspondingly, a function present in a ZigBee device but not available in the JenNet-IP device will not be controllable from the MIB. When viewing the MIB structures with the web server present on the host processor, those settings which do not have a corresponding setting in a ZigBee device will be shown as present but disabled.

2 Capabilities

For the purposes of the demonstration, only the web server present in the Gateway is used to control the devices in the ZigBee network. There are two reasons behind this recommendation: firstly, it can be guaranteed that a self-contained solution will work in most environments by avoiding the need to configure an unfamiliar IT network, and secondly because to use a native application on a client requires such an application to be written.

Due to the number of platforms (smartphones, tablets etc) that exist and their different programming requirements it is not possible to supply an example native application which would be suitable for these platforms.

The Gateway can be configured to behave in one of 3 roles:

- ZigBee Home Automation (ZHA) Coordinator (default)
- ZigBee Light Link (ZLL) Control Bridge
- Combined ZHA Coordinator and ZLL Control Bridge

As a ZHA Coordinator, the Gateway can accept ZHA devices in a classical join, and also ZLL devices which know the ZHA network key.

As a ZLL Control Bridge, the Gateway can accept ZLL devices joining either using classical join or Touchlink: ZHA devices cannot join unless they know the ZLL network key, which currently is not allowed.

As a Combined Coordinator and Control Bridge, the Gateway can recognise and accept devices with either a ZLL or ZHA network key, meaning that ZLL and ZHA lights can join classically and ZLL lights can be Touchlink joined as well. This mode is not provided in the ZigBee specifications but has been added to make it easier to demonstrate a mix of ZLL and ZHA lights together.

The supplied binaries implement a ZLL colour on/off/dimmable light and a ZHA monochrome on/off/dimmable light, which allow demonstration of the control of individual lights in terms of on, off, brightness and colour, and also show the control of groups of lights and scenes.

These operations are performed through the SmartDevices web pages served by the Gateway.

3 What is Provided

The demonstration package comes with the following components, intended to be used with the hardware in the JN516x-EK001 Evaluation Kit:

- Documentation (this document, and Host and Control Bridge documentation)
- Binaries for the Evaluation Kit nodes
  - ZLL on/off/dimmable colour light (**Light_ExtendedColorLight_JN5168_DR1175.bin**)
  - HA on/off/dimmable monochrome light (**DimmableLight_JN5168_DR1175.bin**)

From the source code supplied for the Host and Control Bridge components, it is possible to create the firmware required for the various platforms that can be used for the Gateway. See the Host and Control Bridge documentation for instructions on how to create this firmware. However, for convenience, binaries for the Control Bridge on the JN5168 and the supported Host hardware platforms are provided as part of the Application Note package in the top-level Binaries directory.

4 Configuring the Evaluation Kit Hardware

4.1 Linksys Router

4.1.1 Setting up the Linksys WRT160NL in a New Kit

This section describes the procedure for configuring a Linksys Router, as delivered with the Evaluation Kit i.e. programmed with JenNet-IP firmware. Replacing the original router firmware with the ZigBee IoT Gateway Host binary results in some of the pages described below being changed. Appendix A “Modifying the ZigBee IoT Gateway configuration” describes the same procedures, but includes screenshots generated by the Gateway previously programmed with a version of the ZigBee IoT Gateway firmware.

When configuring JN-RD-6040 IoT Gateway hardware, refer to Appendix A. The JN-RD-6040 IoT Gateway is supplied with firmware similar to the ZigBee IoT Gateway.

The following instructions assume that the appropriate firmware for Host and Node have been generated previously.

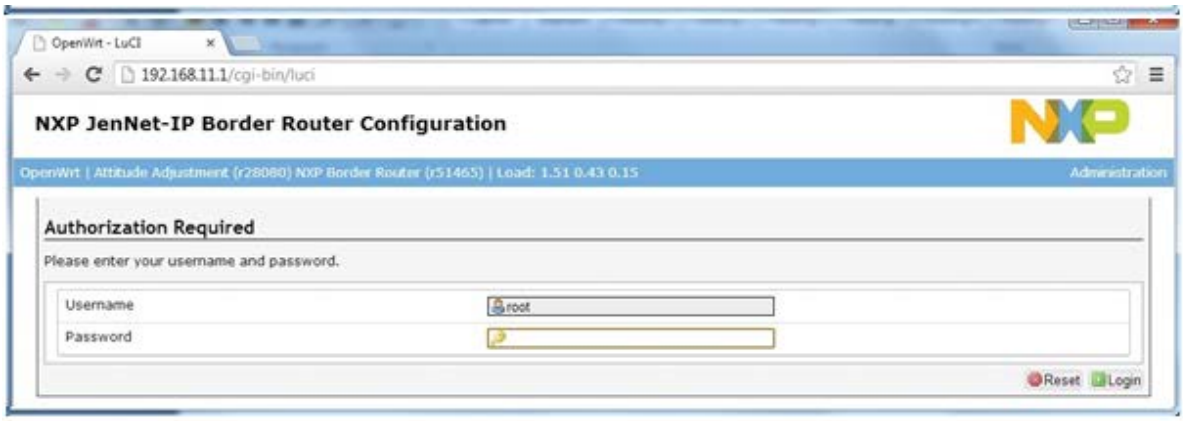
To program the ZigBee Gateway (ZGW) binary into the Flash memory of the Linksys router, perform the following actions:

1 Plug in the Linksys power supply and apply power to the router.

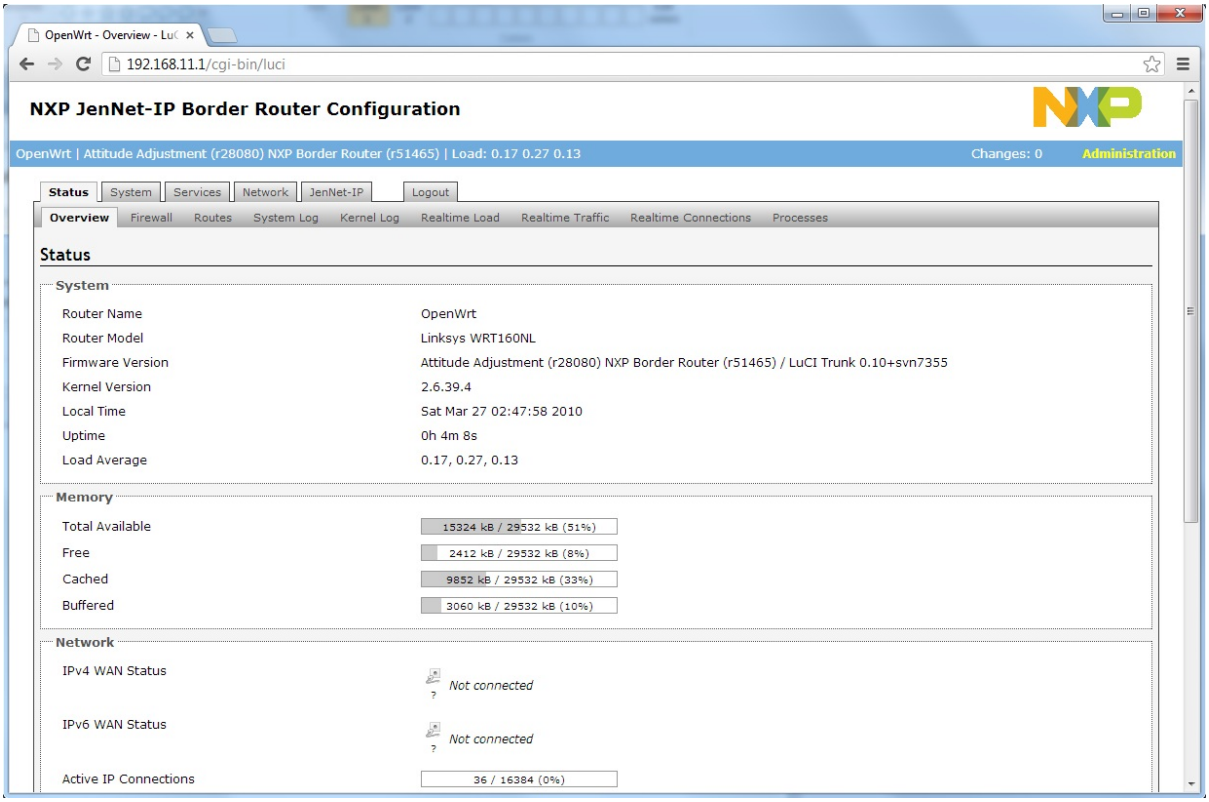
2 Plug an Ethernet cable into one of the router ports marked 1 to 4.

3 Connect the other end of the Ethernet cable to a laptop computer or PC.

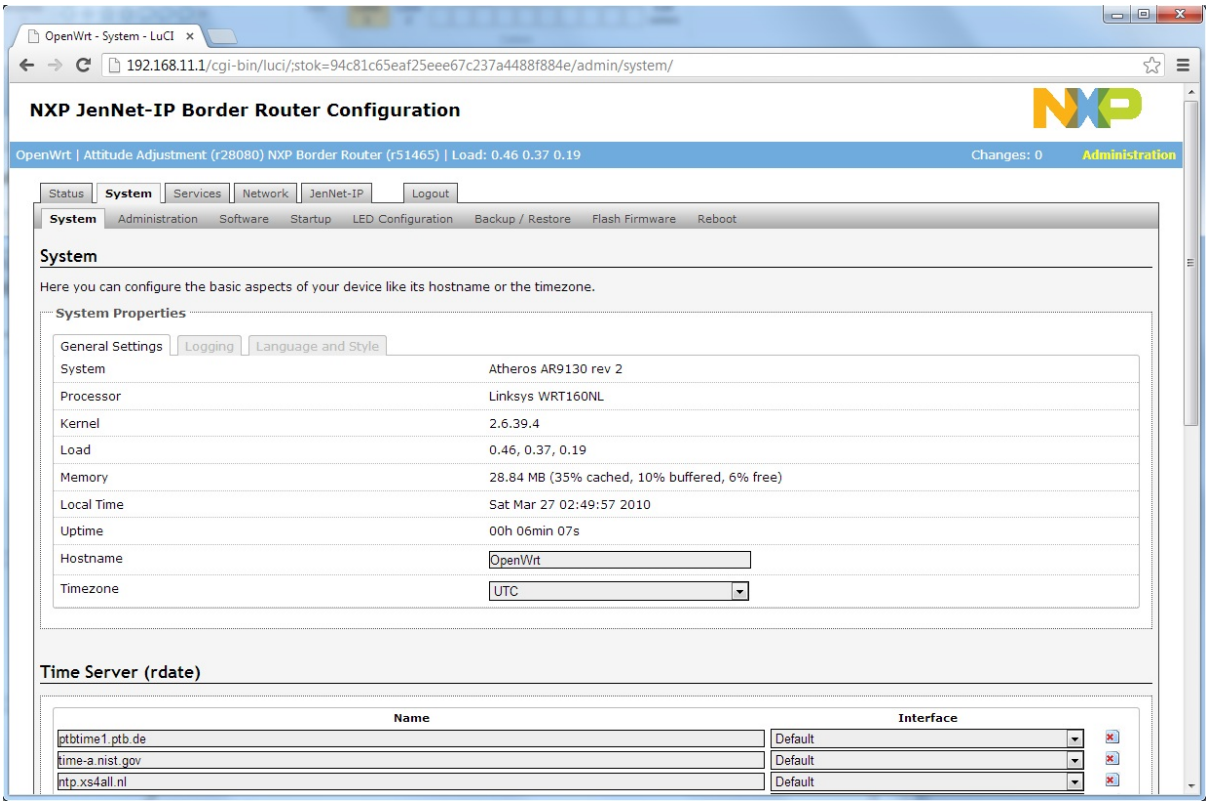
4 In a web browser, navigate to the IP address 192.168.11.1. You will see the following screen (the “landing screen”).



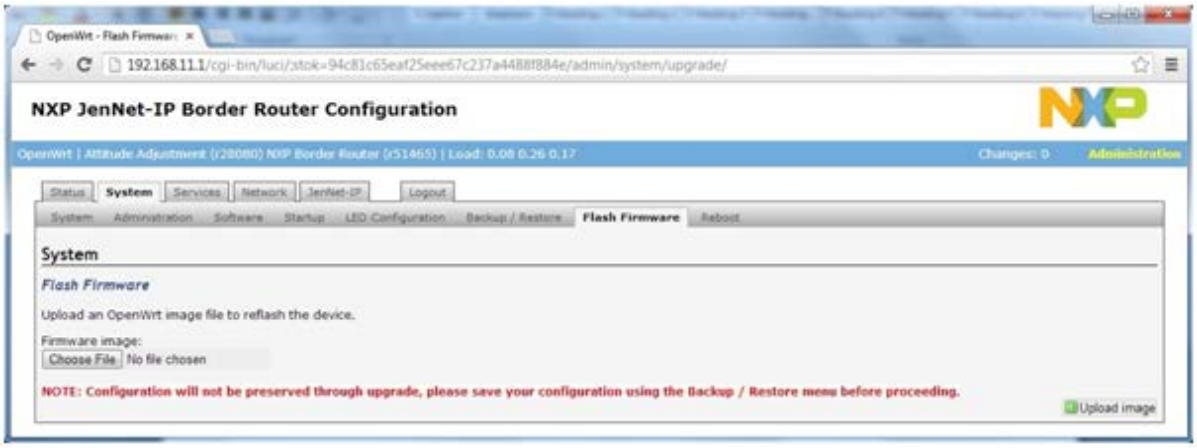
5 Login to the Gateway using the username “root” and the password “snap”. You will see the “Border Router Configuration” screen.



6 Select (click on) the “System” tab.



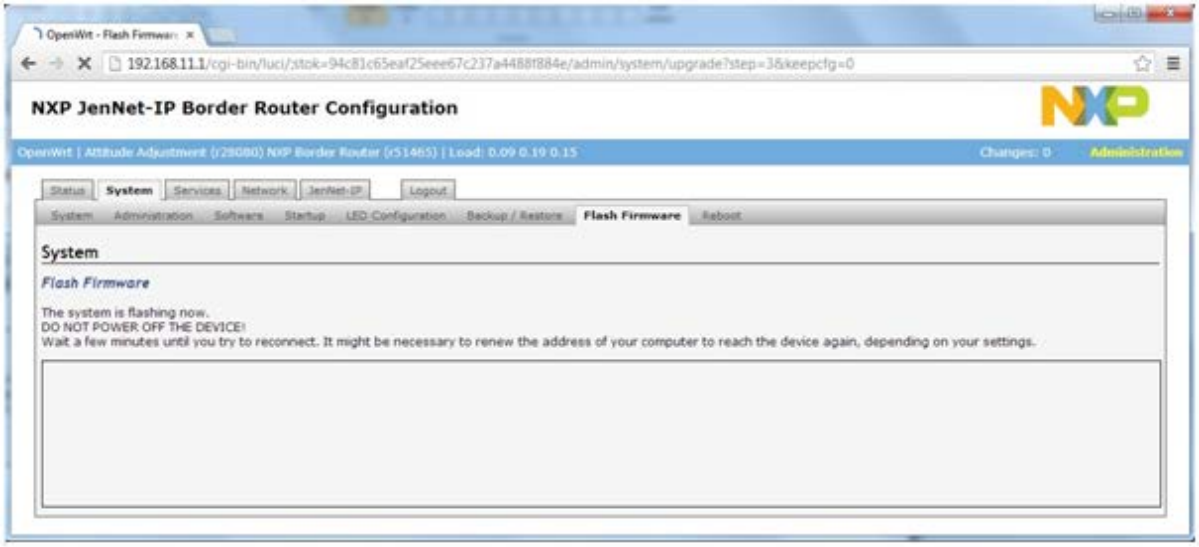
7 Select “Flash Firmware” then click “Choose file”.



Browse for the location of the Linksys Host binary file, select and then click “Open”.

8 Click “Upload Image” – this will display the “Flash Firmware” page which allows you to check the size and checksum of the image.

9 Click “Proceed” to start the memory update process. The following screen is displayed:



> **!** *DO NOT TURN OFF POWER TO THE ROUTER UNTIL THE UPDATE IS COMPLETE.*

During the reprogramming process, the power LED begins to flash and then stays lit. This is then followed by the bar LED below the Linksys logo starting to flash. When this LED stops flashing and remains illuminated, the reprogramming and associated reboot has completed, meaning that the Router can be contacted again.

> NOTE: Reprogramming the Router will return all settings for the Router and Control Bridge back to their defaults. It may be necessary to re-enable Wi-Fi and change the operating channel of the Control Bridge. The following sections explain how to make these changes.

4.1.2 Setting up a Wi-Fi Connection

It may be necessary to enable the Wi-Fi network on the Router if you want to use a Wi-Fi-enabled smartphone or tablet to control the demonstration.

This operation is not supported on the JN-RD-6040 Gateway.

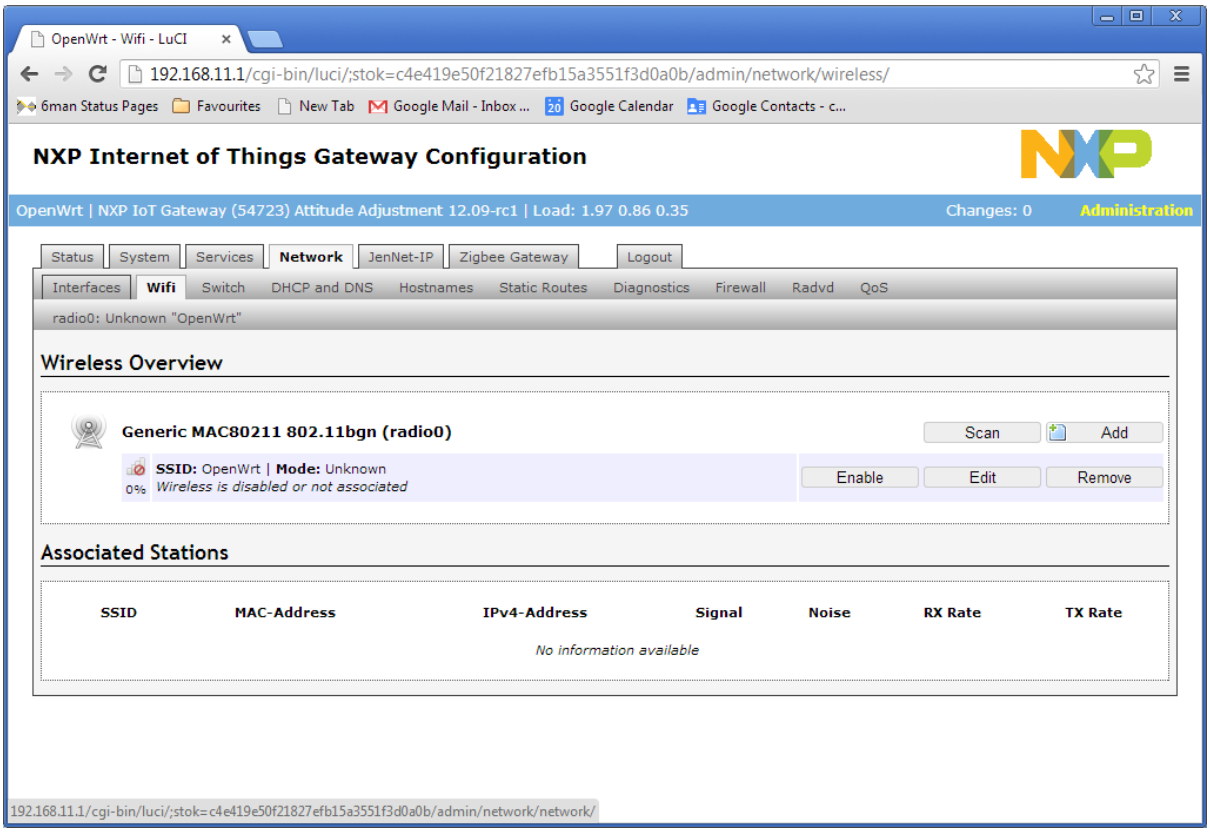
To activate Wi-Fi, navigate to the Router login atl screen at 192.168.11.1.

1 Click on the “Gateway Configuration Interface” link.

2 Login to the Gateway using the username “root” and the password “snap”.

3 You will see the “Gateway Configuration” screen.

4 Click the “Network” tab and then click the “Wifi” tab.



5 Click “Edit” to change the settings for the Wi-Fi interface.

6 In the “Device Configuration” section, edit the Channel and Transmit Power settings.

Select a channel that will not interfere with any systems that may be operating in the vicinity and preferably one which does not interfere with the IEEE 802.15.4 channels used by ZLL. Wi-Fi channels 1, 6 and 11 are good candidates.

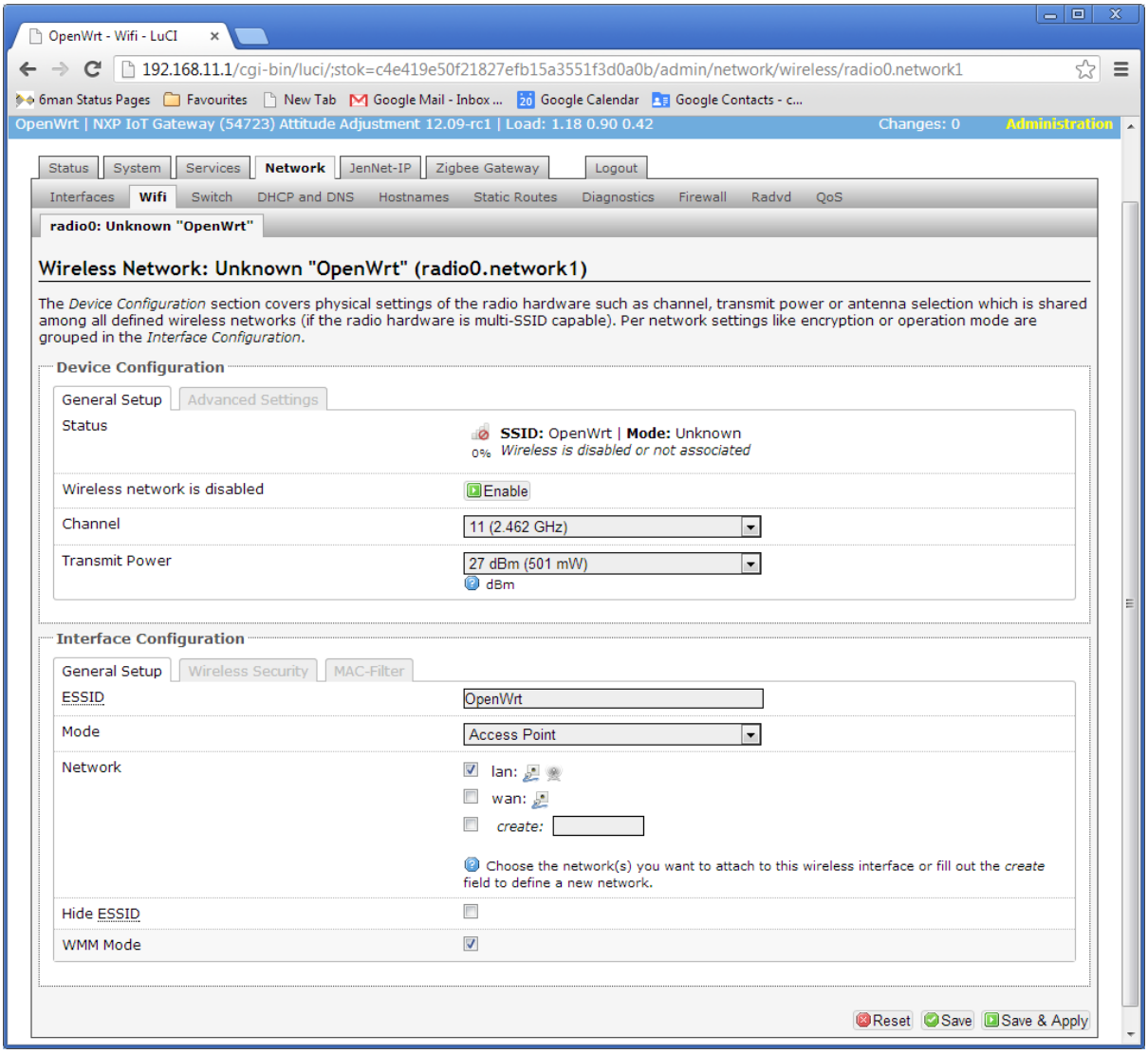
If you know that the Wi-Fi device controlling the demonstration will be reasonably close to the Router hardware, reduce the power output of the Wi-Fi to between 0 and 7dBm (1-5mW).

Click “Enable” to enable the interface.

7 In the “Interface Configuration” section edit the name that the Router will use for its SSID.

In “ESSID”, type the name you wish to use e.g. “NXP-ZGW”.

Then click “Save and Apply” to apply the settings and activate the Wi-Fi interface.



Test that the Wi-Fi interface is enabled by searching for the name you gave for the ESSID of the Router. It should be visible on the list of available networks on a smart device’s Wi-Fi connection page. Connect to the Router’s Wi-F network; you should be able to use the smart device browser to navigate to 192.168.11.1 and see the landing screen of the Router.

4.2 Setting up the USB Dongle

It is necessary to install the ZigBee Control Bridge software in one of the USB dongles supplied with the Evaluation Kit. This software binary is built from the sources supplied with the Application Note. See document JN-AN-1194 “ZigBee IoT Gateway – Control Bridge” for instructions on how to build this binary.

The software is programmed into the dongle using a JN51xx Flash programming tool, such as the one provided within BeyondStudio for NXP and described in the *BeyondStudio for NXP Installation and User Guide (JN-UG-3098)*.

The USB dongle should be plugged into the USB port of the Linksys Router. The USB device is not hot-pluggable, and requires the Router to be rebooted or power-cycled for the dongle to be recognised.

4.3 RD6040 "Internet of Things" Gateway

4.3.1 Connecting the RD6040 Gateway

Unlike the Linksys router, the RD6040 IoT Gateway (RD6040 Gateway) is not intended to be used standalone, but as an addition to an existing home network controlled by a SOHO router. As a consequence, in order to demonstrate the RD6040 Gateway, it is necessary to use a suitable router (e.g. the Linksys WRT160NL from the JN516x-EK001 Evaluation Kit) to provide the services that a home router would provide.

Power on the Linksys router and allow it to boot up. The bar LED below the Linksys logo starts to flash. When this LED stops flashing and remains illuminated, the boot process has completed.

Connect the RD6040 Gateway to its power supply (PSU) and plug the PSU into the mains. Connect the RD6040 Gateway Ethernet port to one of the four Ethernet ports on the Linksys router using an Ethernet cable. Allow the RD6040 Gateway to boot up; the LEDs on the gateway indicate the following:

- The Yellow LED when flashing indicates that the gateway is booting; when the boot process has completed the LED remains lit.
- The Red LED flashes regularly, showing that the Linux kernel is up and running.
- The Green LED shows activity on the Ethernet.
- The Blue LED indicates when power is applied.

4.3.2 Finding the IP Address of the RD6040 Gateway

One of the services that the RD6040 Gateway needs from the home network router is DHCP, to obtain an IP network address. This address is also required by the user to connect to the web server in the RD6040 Gateway. If using the Linksys as the DHCP source, the address allocated by its DHCP server can be found as follows:

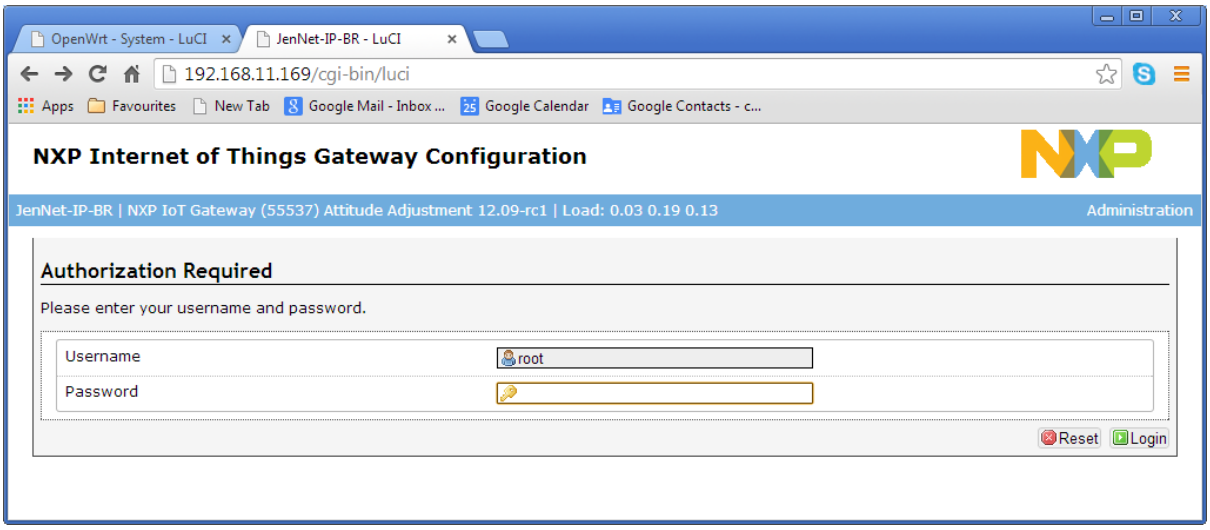
1 In a web browser, navigate to the Linksys router (192.168.11.1) and log in. Depending on the version of the firmware running on the Linksys, the login page will be presented or you will need to choose the "Gateway Configuration Interface" link. Login using the username "root" and the password "snap".

2 Under the Status tab, select Overview and scroll down to the DHCP section. Here you will find two or more entries. One will be the PC or tablet running the browser and the other will be the RD6040 Gateway. Both will have an IPv4 address beginning 192.168.11. Note the address allocated to the RD6040 Gateway; this is the address to use when communicating with the RD6040 Gateway, for example, when using a browser. This address is referred to in the following sections as 192.168.11.x

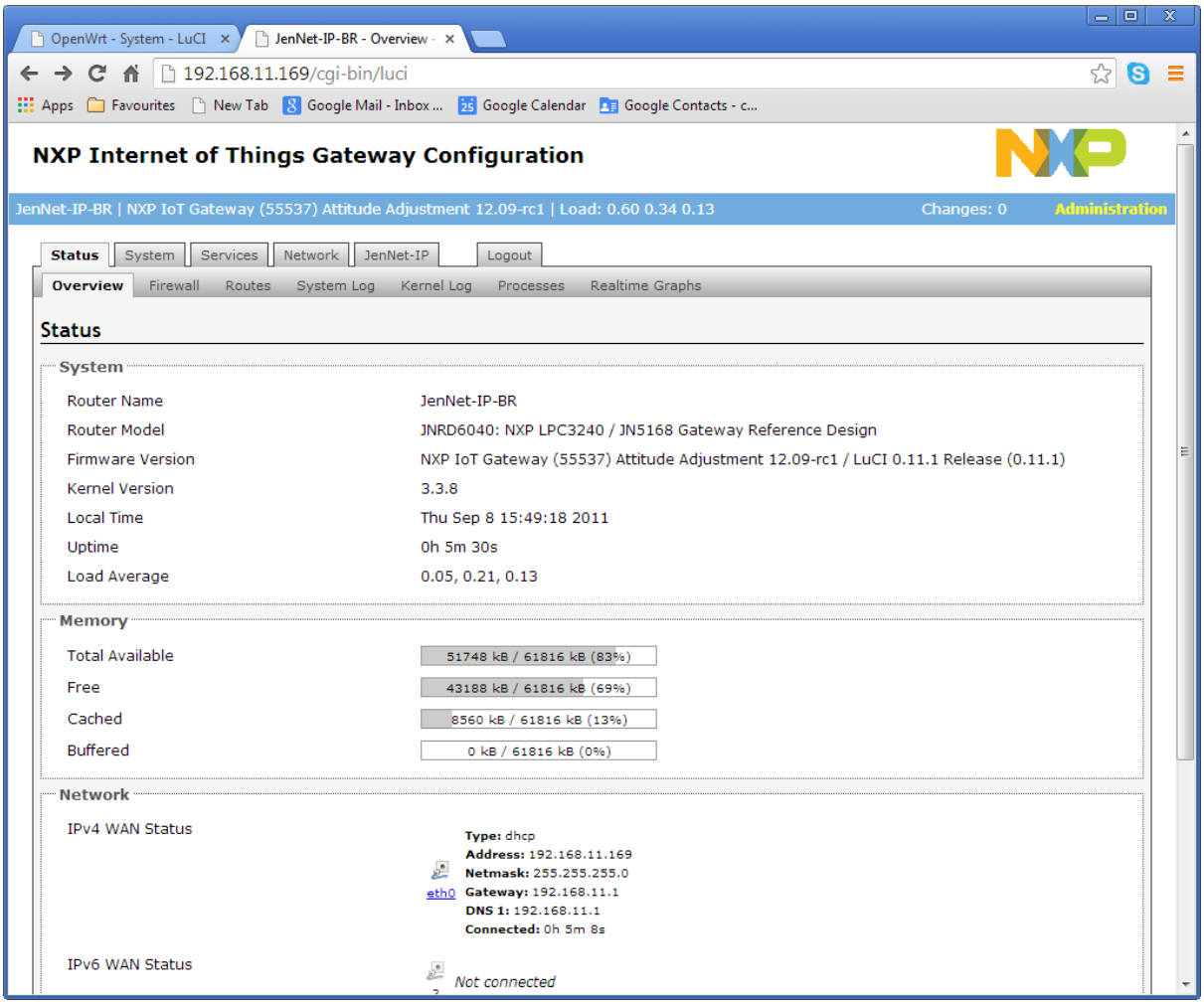
4.3.3 Setting up the IoT Gateway Host processor in a New Kit

On delivery, the RD6040 Gateway is programmed with firmware for a JenNet-IP Border Router. This firmware needs to be replaced with firmware for the ZigBee IoT Gateway. The following steps describe the process which must be followed:

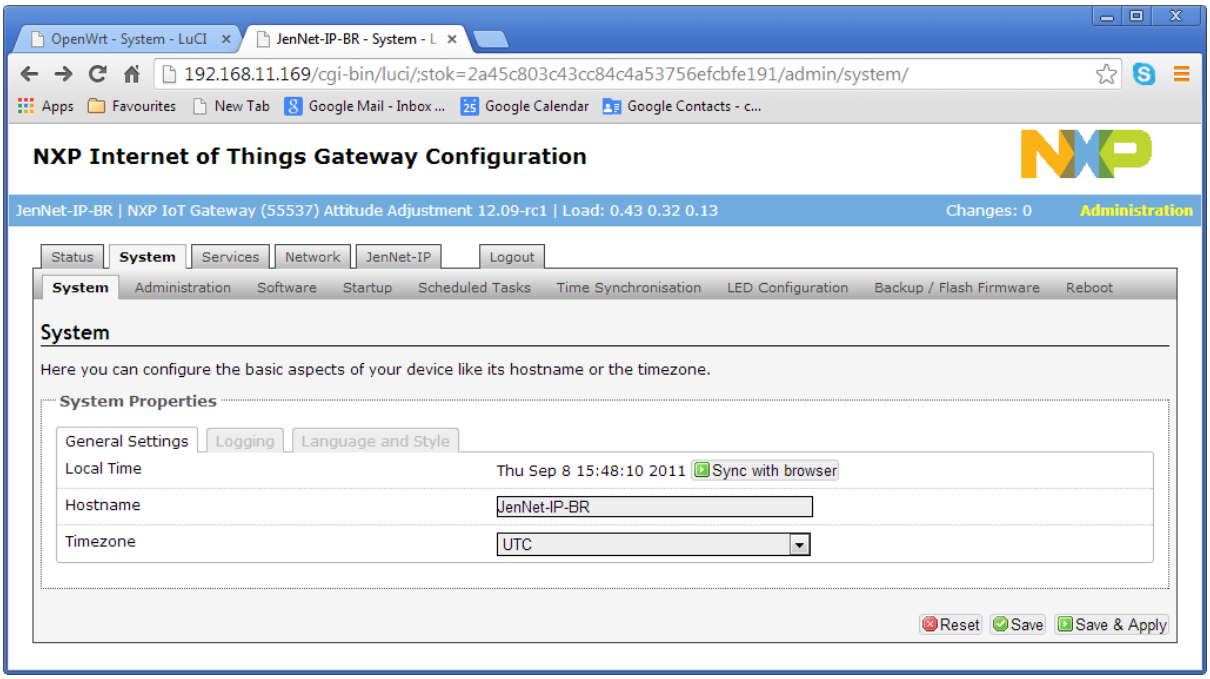
1 In a web browser, navigate to the IP address 192.168.11.x. You will see the following screen (the “landing screen”).



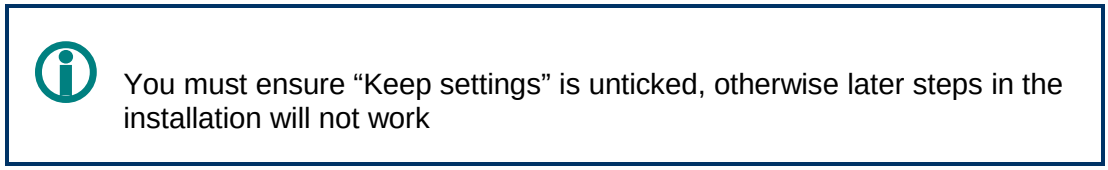
2 Login to the Gateway using the username “root” and the password “snap”. You will see the “IoT Gateway Configuration” screen.



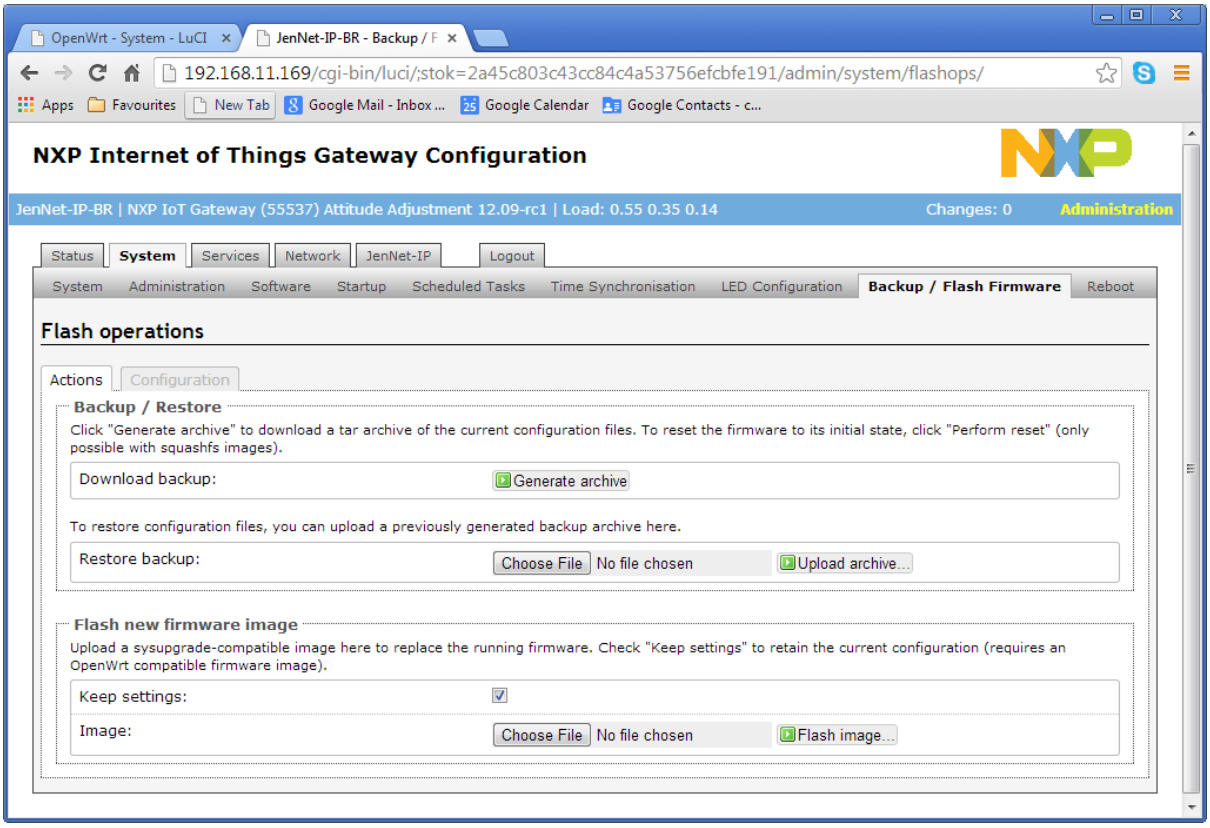
3 Select (click on) the “System” tab.



4 Select the “Backup / Flash Firmware” tab. In the “Flash new firmware image” section, untick the “Keep settings” tick-box, and then click “Choose file”.



You must ensure “Keep settings” is unticked, otherwise later steps in the installation will not work

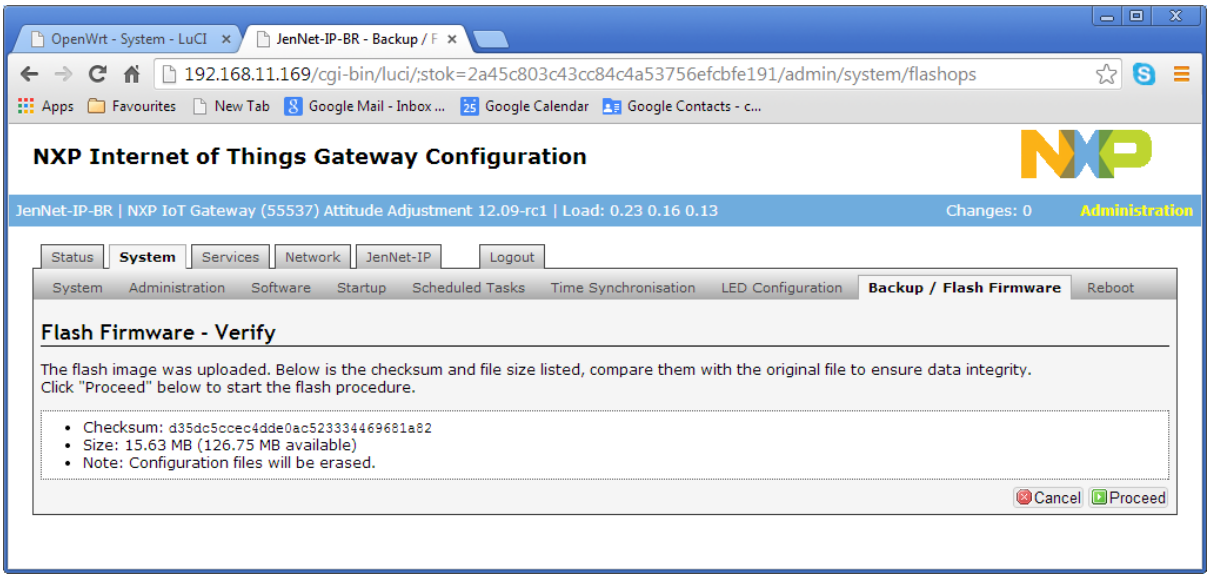


Browse for the location of the JNRD6040 Host binary file, select and then click “Open”. In the Application Note package, the binary file is found in directory

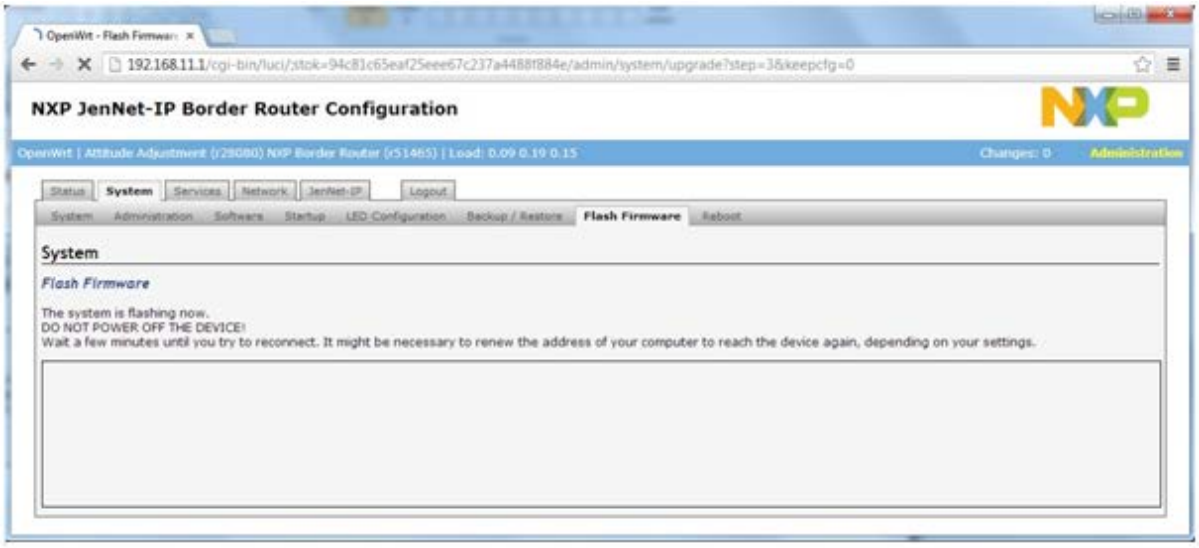
..\Build\Host\NXP IoT Gateway JNRD6040

and has filename **openwrt-lpc32xx-JNRD6040--jffs2-sysupgrade.bin**.

5 Click “Flash Image” – this will display the “Flash Firmware” page which allows you to check the size and checksum of the image.



6 Click “Proceed” to start the memory update process. The following screen is displayed:



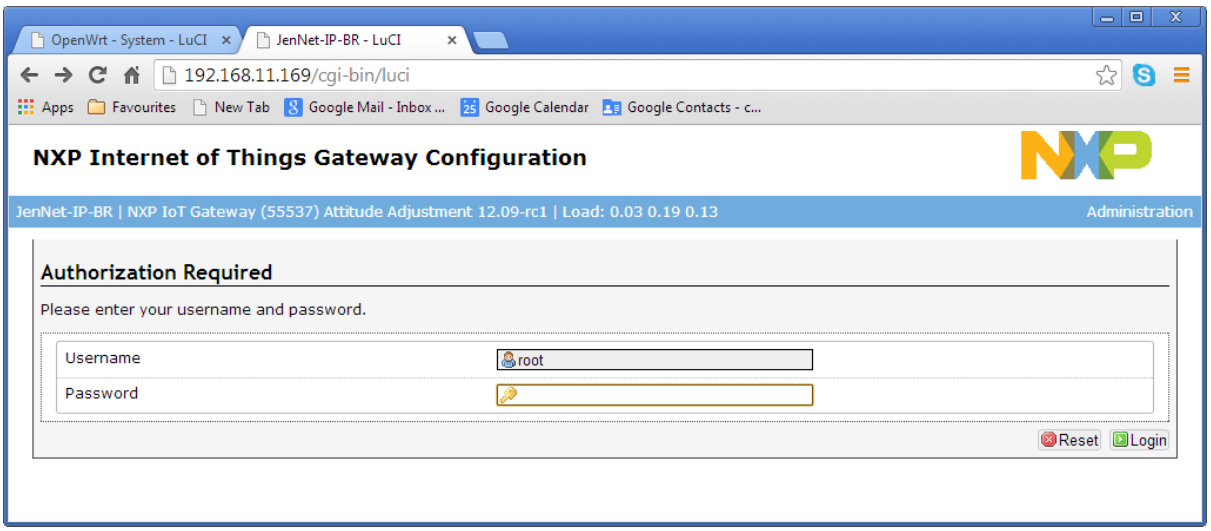
> **!** *DO NOT TURN OFF POWER TO THE GATEWAY UNTIL THE UPDATE IS COMPLETE.*

During the programming process the second and third LEDs from the left (yellow and red respectively) will flash; at the end of the process the fourth LED (green) will start to flash. This shows that the Gateway has rebooted and is communicating on the Ethernet interface. At this point you may need to navigate to the address of the IoT Gateway (192.168.11.x) with the browser in order to make contact with the Gateway again. If this does not work, recheck the address of the Gateway as described in Section 4.3.2 “Finding the IP Address of the RD6040 Gateway”.

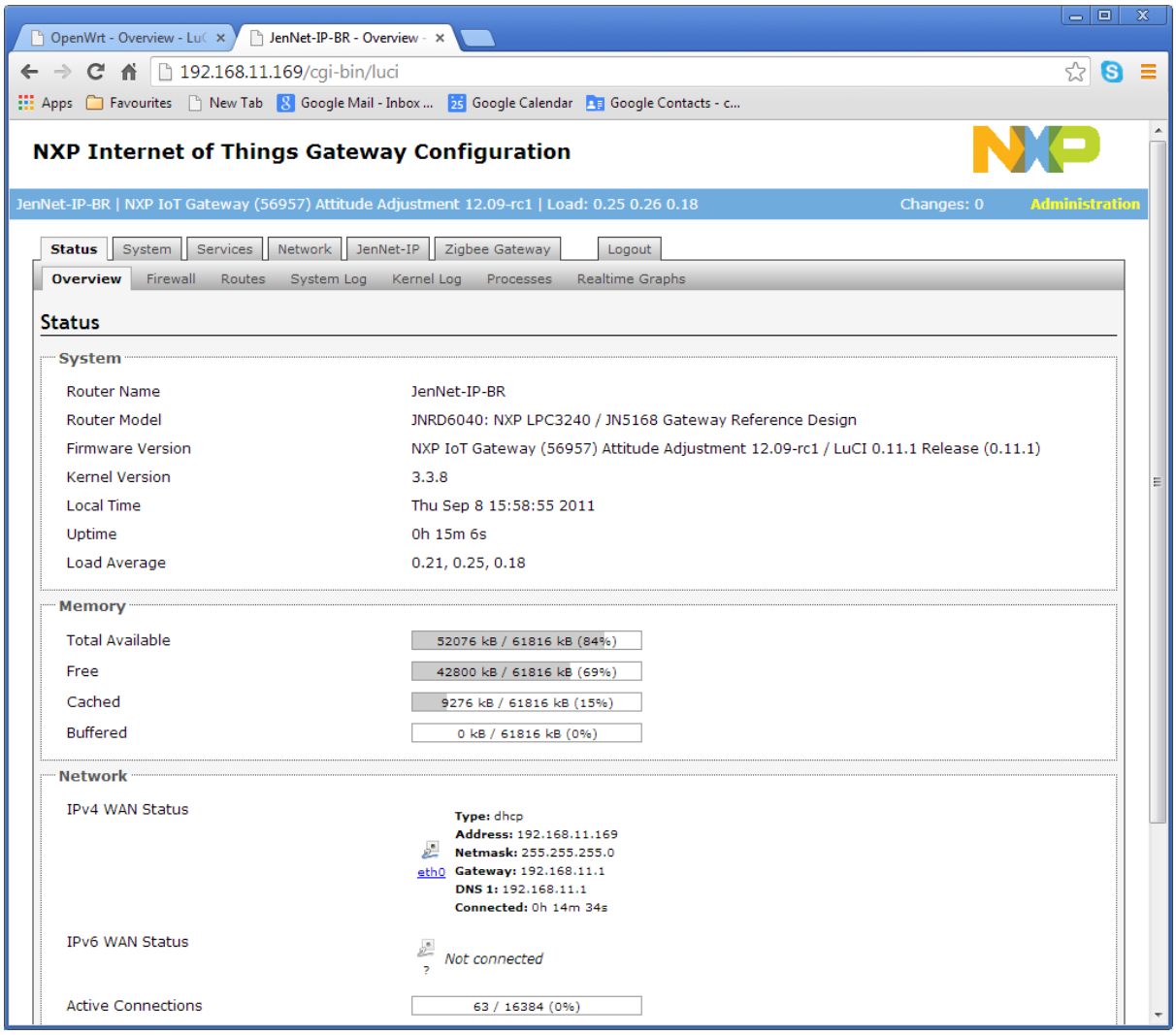
4.3.4 Changing Serial Port and Baud Rate

The first time that the RD6040 Gateway is used as a ZigBee IoT Gateway, the configuration file for the zigbee-jip-daemon process needs to be changed. As delivered it is set up for using a JN5168 in a USB dongle rather than the internal JN5168. To set up the hardware to use the internal JN5168, perform the following procedure:

1 In a web browser, navigate to the IP address 192.168.11.x, to see the “landing screen”.

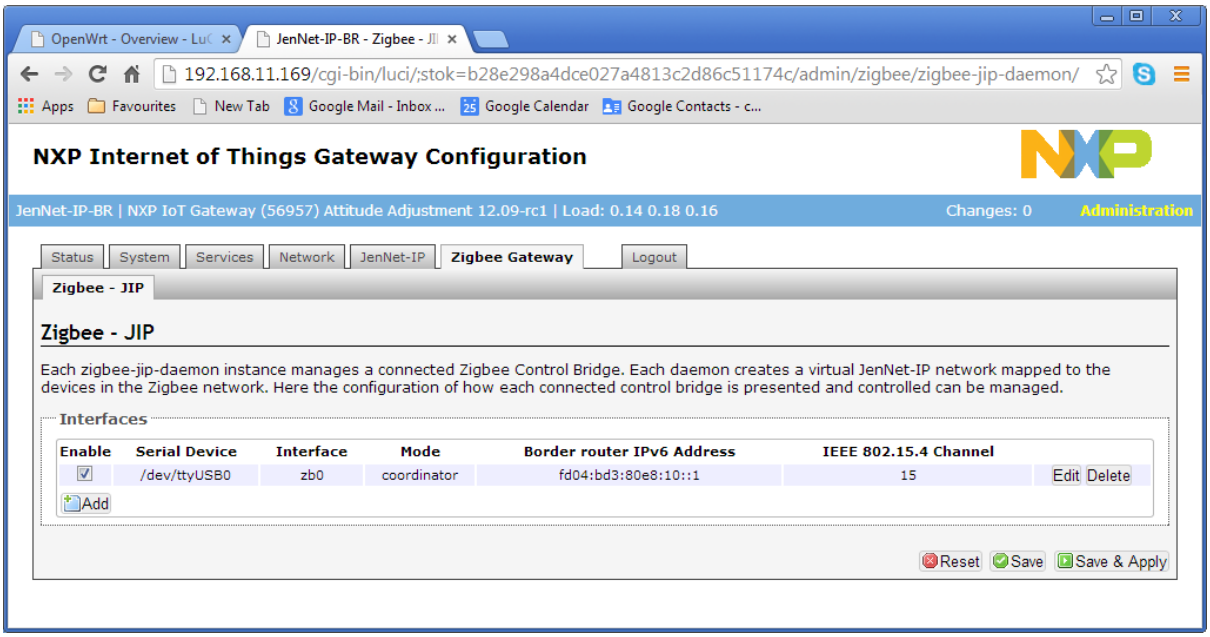


2 Login to the Gateway using the username “root” and the password “snap”. You will see the “IoT Gateway Configuration” screen.

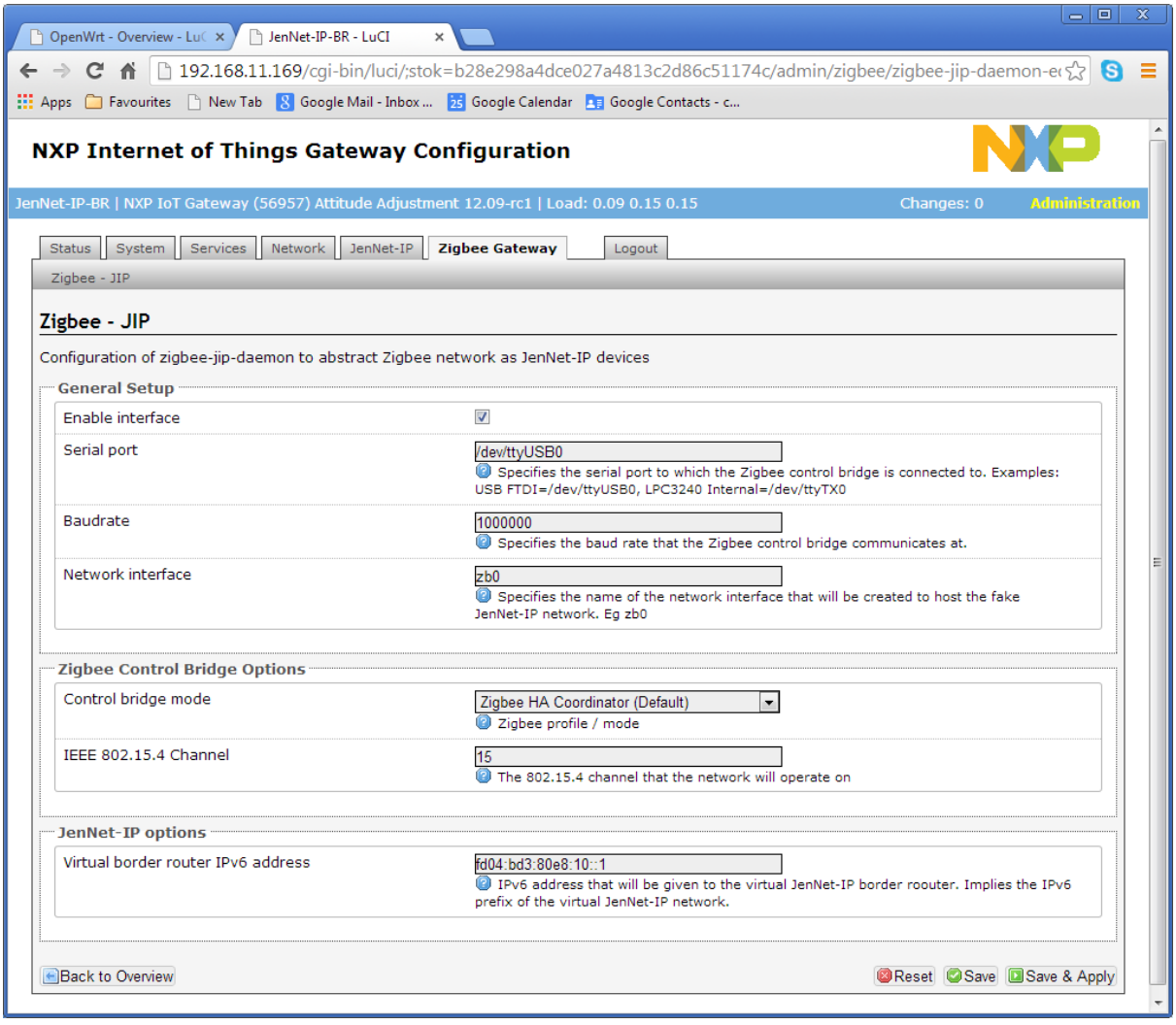


3 Click on the “ZigBee Gateway” tab

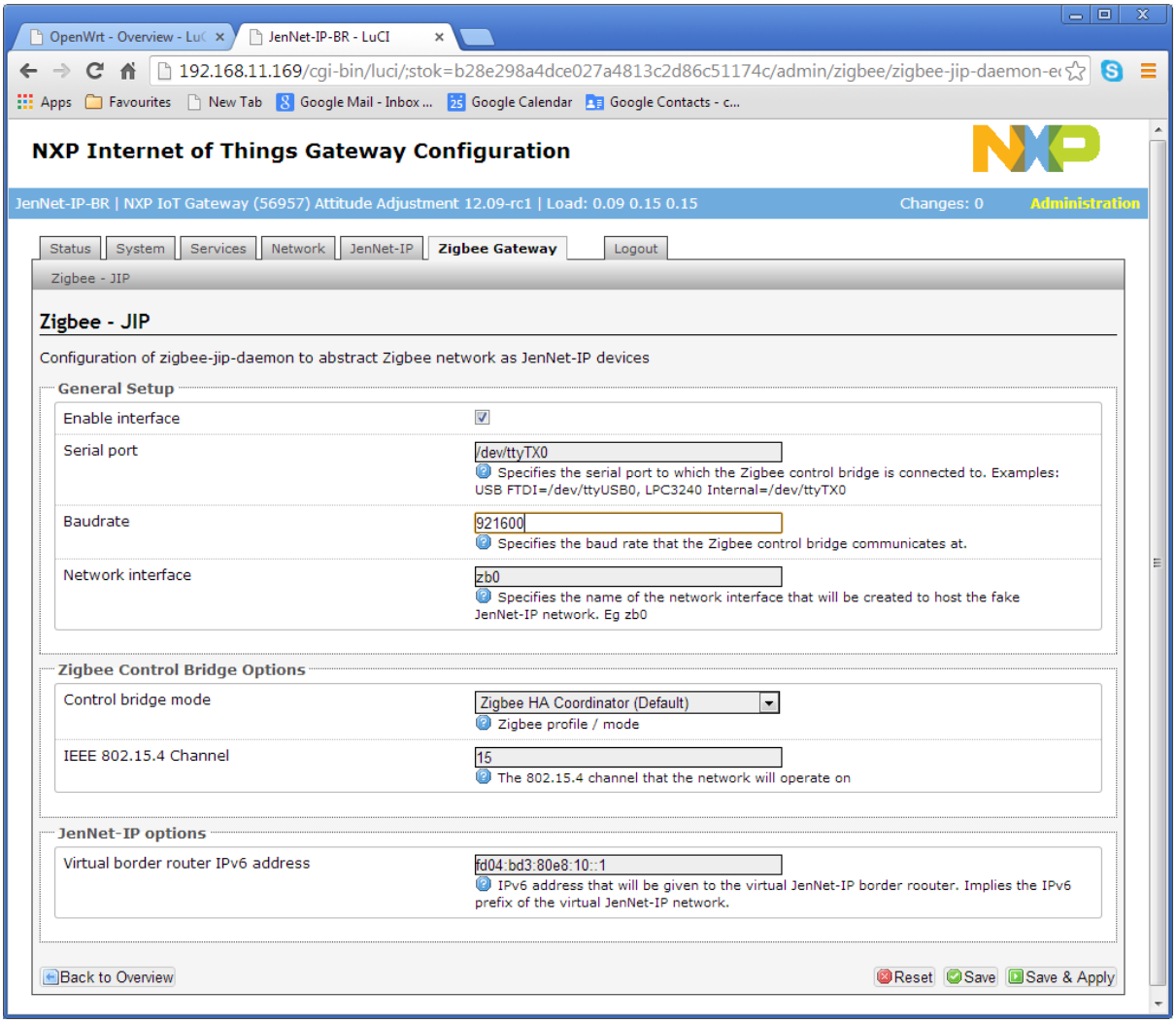
4 Then click on the “Zigbee-JIP” tab



5 Edit the zb0 interface by clicking the “Edit” button



5 To change the gateway to use the correct serial device and baudrate, enter /dev/ttyTX0 in the “Serial port” text box, and 921600 in the “Baudrate” text box, then click on “Save and Apply”



This changes the settings in the **/etc/config/zigbee-jip-daemon** file. This file is used at boot-up to determine the settings of the zigbee-jip-daemon. Once changed, it does not need to be altered again, unless it is required to return to using a JN5168 in a USB dongle.

These changes will take effect the next time the Gateway is rebooted or the zigbee-jip-daemon is restarted (using the command “`/etc/init.d/zigbee-jip-daemon start`” when logged into the Gateway command line as shown in the following section)

4.3.5 Programming the ZigBee Control Bridge Software

It is necessary to install the ZigBee Control Bridge software in the internal JN5168 of the RD6040 Gateway. This software binary file is built from the sources supplied with the Application Note. See the document “JN-AN-1194 ZigBee IoT Gateway – Control Bridge” for instructions on how to build this binary.

1 To program the binary into the JN5168, it is necessary to first transfer the binary from the PC where it was built into a location in the filesystem of the RD6040 gateway. This can be achieved by using the secure copy protocol (SCP), implemented in a secure copy client such as the `pscp` program (other secure copy clients are available)

2 As an example of the secure copy, we will copy the Control Bridge binary to **/tmp** directory of the RD6040 Gateway at 192.168.11.169 using the pscp program from a Windows command prompt:

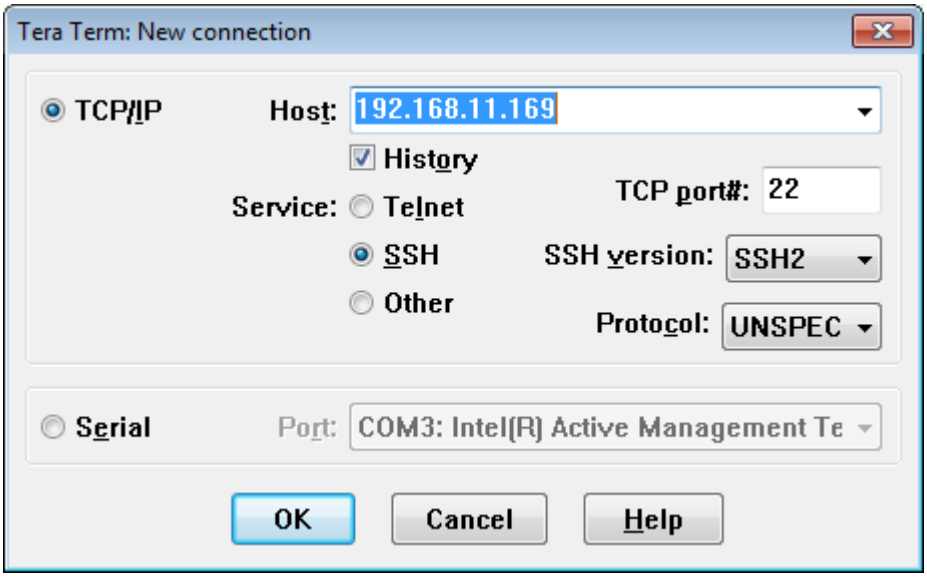
```
C:>pscp C:\ZigbeeNodeControlBridge.bin root@192.168.11.169:/tmp
The servers's host key is not cached in the registry. You
Have no guarantee that the server is the computer you think it is
The server's rsa2 key fingerprint is:
ssh-rsa 1039 5b:16:4f:dd:e1:8d:d4:ae:89:8a:52:31:15:cd:a0:79
If you trust this host, enter "y" to add the key to PuTTY's cache
and carry on connecting.
If you want to carry on connecting just once, without adding the key
to the cache, enter "n".
If you do not trust this host, press Return to abandon the
connection.
Store key in cache? (y/n) y
root@192.168.11.169's password:
ZigbeeNodeControlBridge.b | 190 kB | 190.2 kB/s | ETA: 00:00:00 |
100%

C:>
```

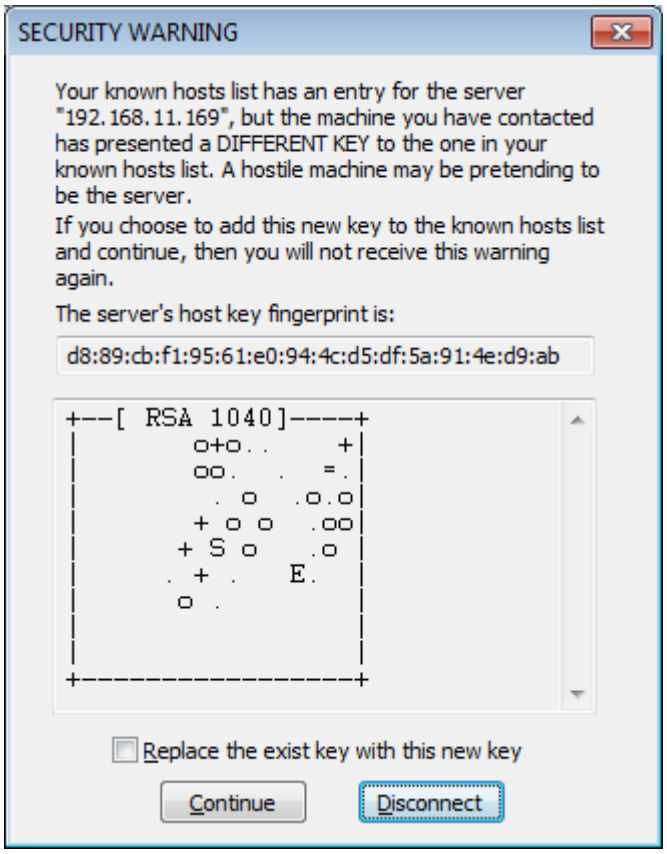
The remote end (the RD6040) verifies tthat the copy has permission to be performed by asking for the user password (user "root", with password "snap") and then copies the file to **/tmp/ZigbeeNodeControlBridge.bin**.

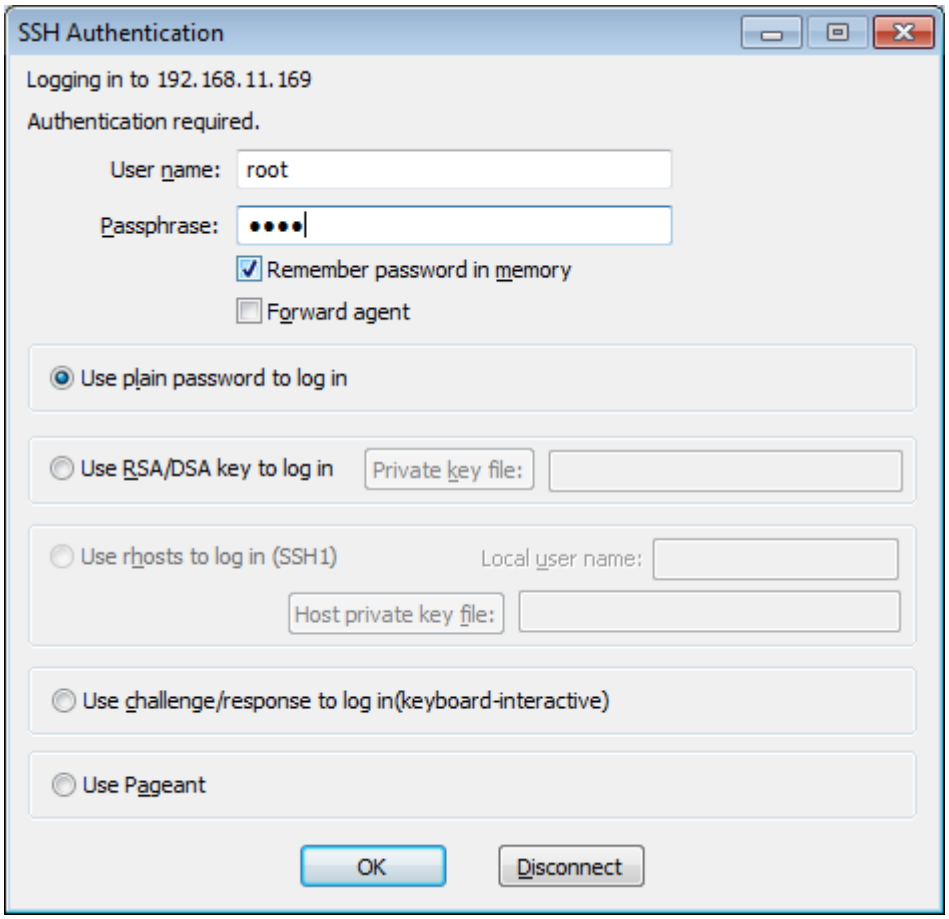
Now that the file is available on the RD6040 Gateway, it is necessary to invoke the built-in JennicModuleProgrammer application on the RD6040 Gateway host to program the firmware into the JN5168.

3 Log in to the RD6040 Gateway using a terminal emulator (here we are using Tera Term) as user "root", password "snap"

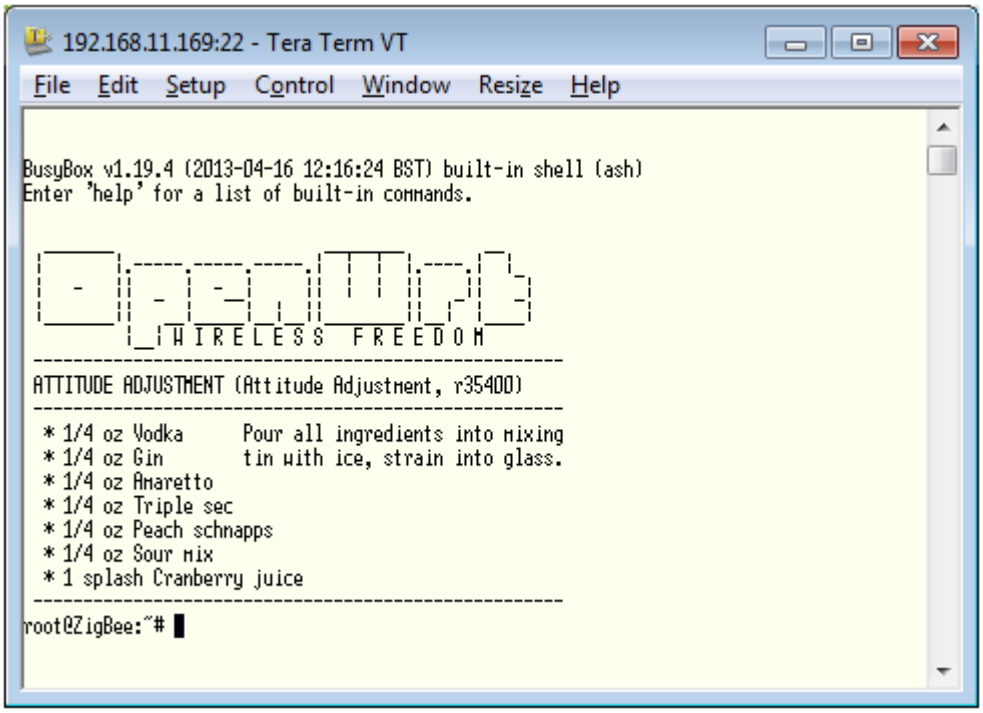


During the connection process to the IP address, if TeraTerm does not have the key or does not know about the Gateway (which will be the case the first time you connect or after the Host firmware has changed), it generates a warning asking if you trust the connection and gives the option of saving the key – you may optionally save the key by ticking the "Replace…" check box. Then click "Continue".





The following screen will be displayed



4 The JennicModuleProgrammer tool is located in the **/usr/bin** directory; change directory to **/usr/bin** using the command

```
cd /usr/bin
```

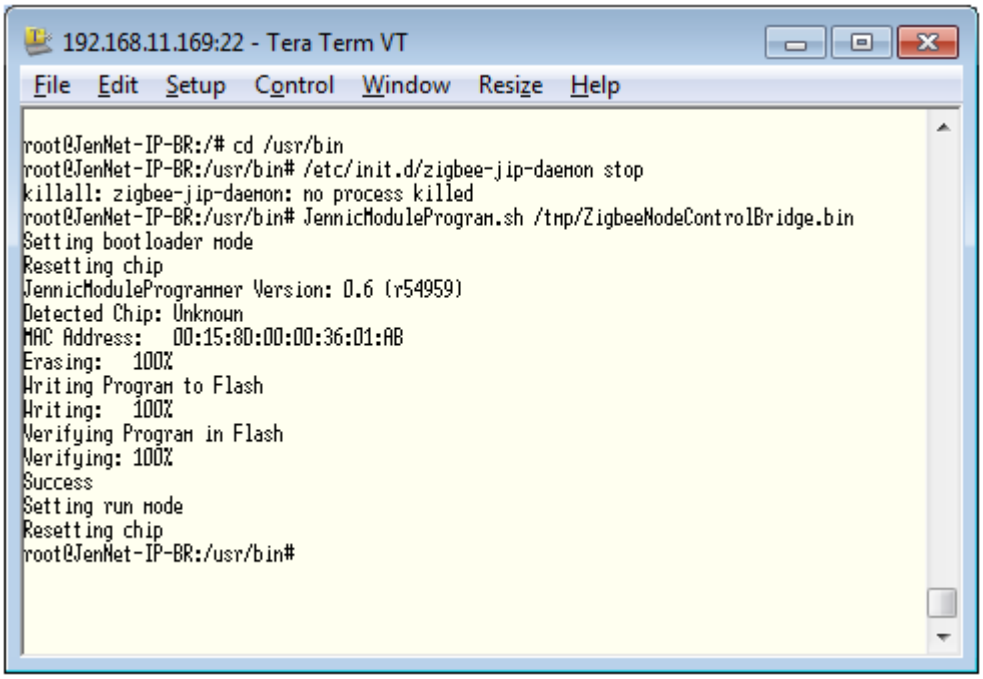
In order to program the module firmware successfully, no other programs must access the serial link between the Host and the JN5168. In normal operation the **zigbee-jip-daemon** process is using the link to communicate between the two devices. Stop the daemon using the command

```
/etc/init.d/zigbee-jip-daemon stop
```

To program the firmware into the JN5168, invoke the **JennicModuleProgrammer** by typing

```
JennicModuleProgram.sh /tmp/ZigbeeNodeControlBridge.bin
```

The following screenshot shows this sequence of commands and the associated output



At this point, the binary file has been programmed into the JN5168 and has been verified to be correct, and the JN5168 has been restarted. For the Gateway to be used, the **zigbee-jip-daemon** process (which was stopped prior to the programming operation) needs to be restarted using the command

```
/etc/init.d/zigbee-jip-daemon start
```

4.4 Common Set-up Operations

The following sections describe operations which are common to both the Linksys WRT160NL and NXP RD6040 IoT Gateway platforms. In the descriptions, IP addresses refer to the Linksys hardware. When using the RD6040 hardware, replace the address 192.168.11.1 with the appropriate value (192.168.11.x) found in section 4.3.1 “Connecting the RD6040 Gateway”. The addresses where substitution is required are marked “192.168.11.1 (x)”

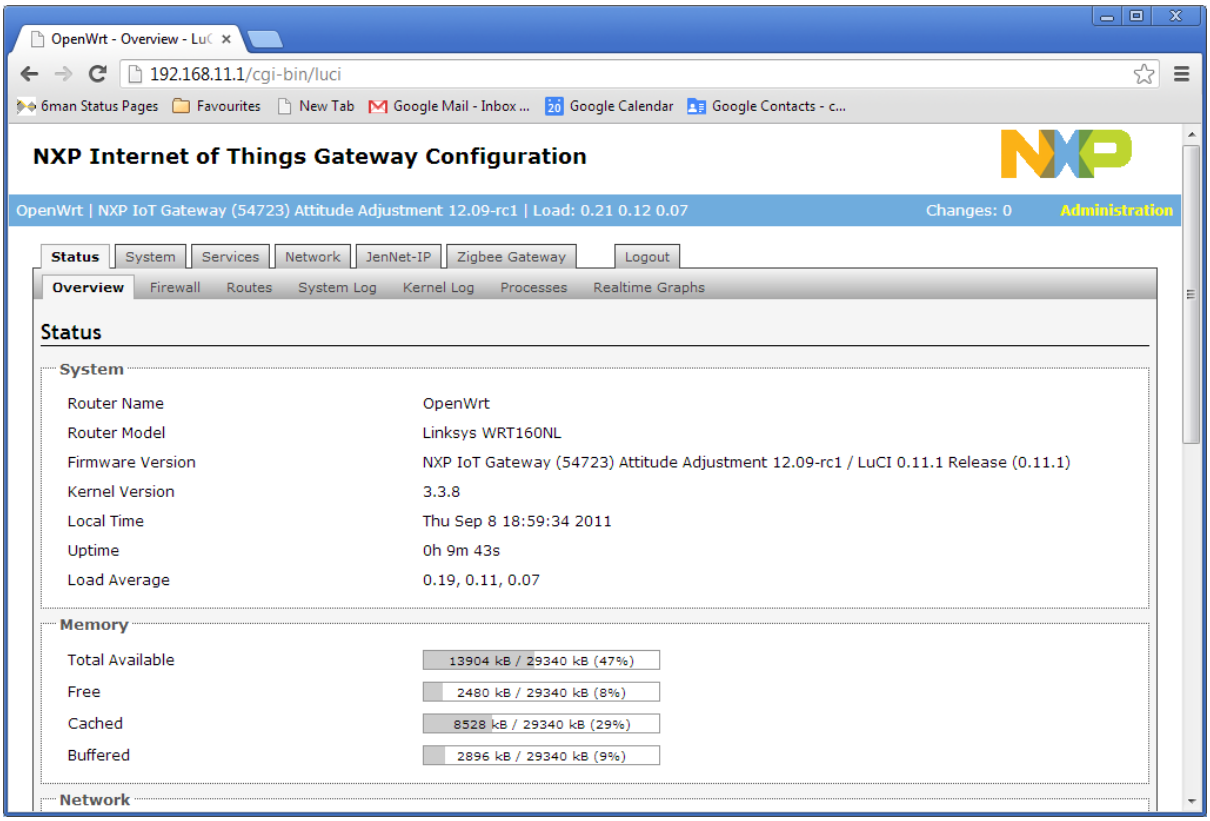
4.4.1 Setting up the ZigBee Network

The default 802.15.4 channel built into the ZigBee IoT Gateway node binary is channel 15.

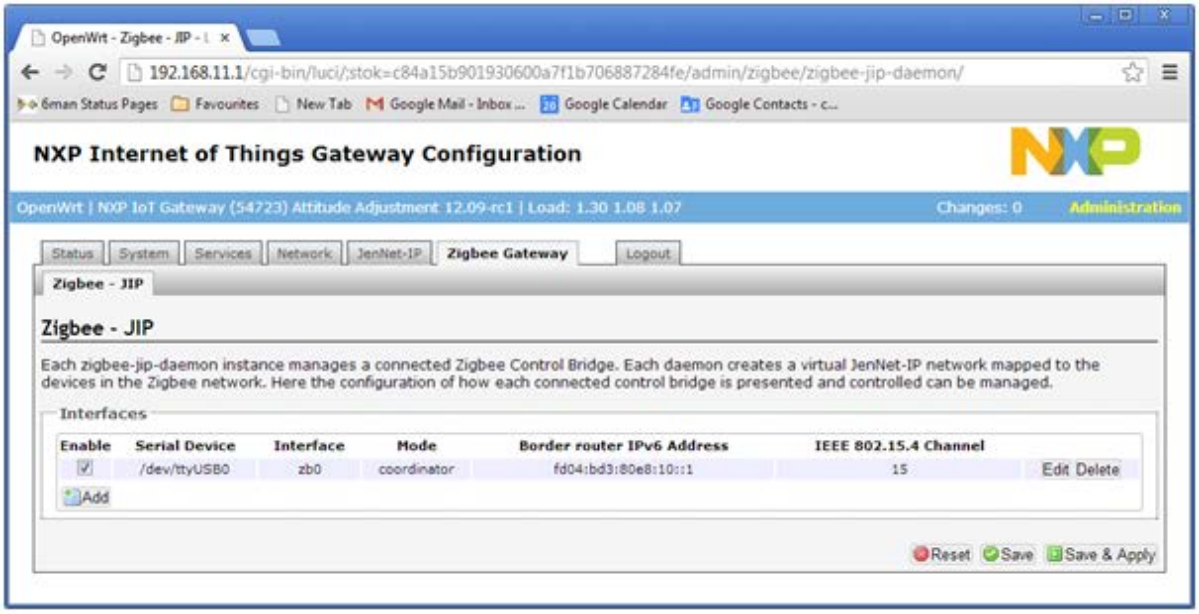
1 Switch on the Gateway (Linksys Router with the dongle plugged into the USB socket or RD6040 Gateway hardware). After the hardware has booted, navigate to the landing page at 192.168.11.1(x) and click on the “Gateway Configuration Interface” link.

Login to the Gateway using the username “root” and the password “snap”.

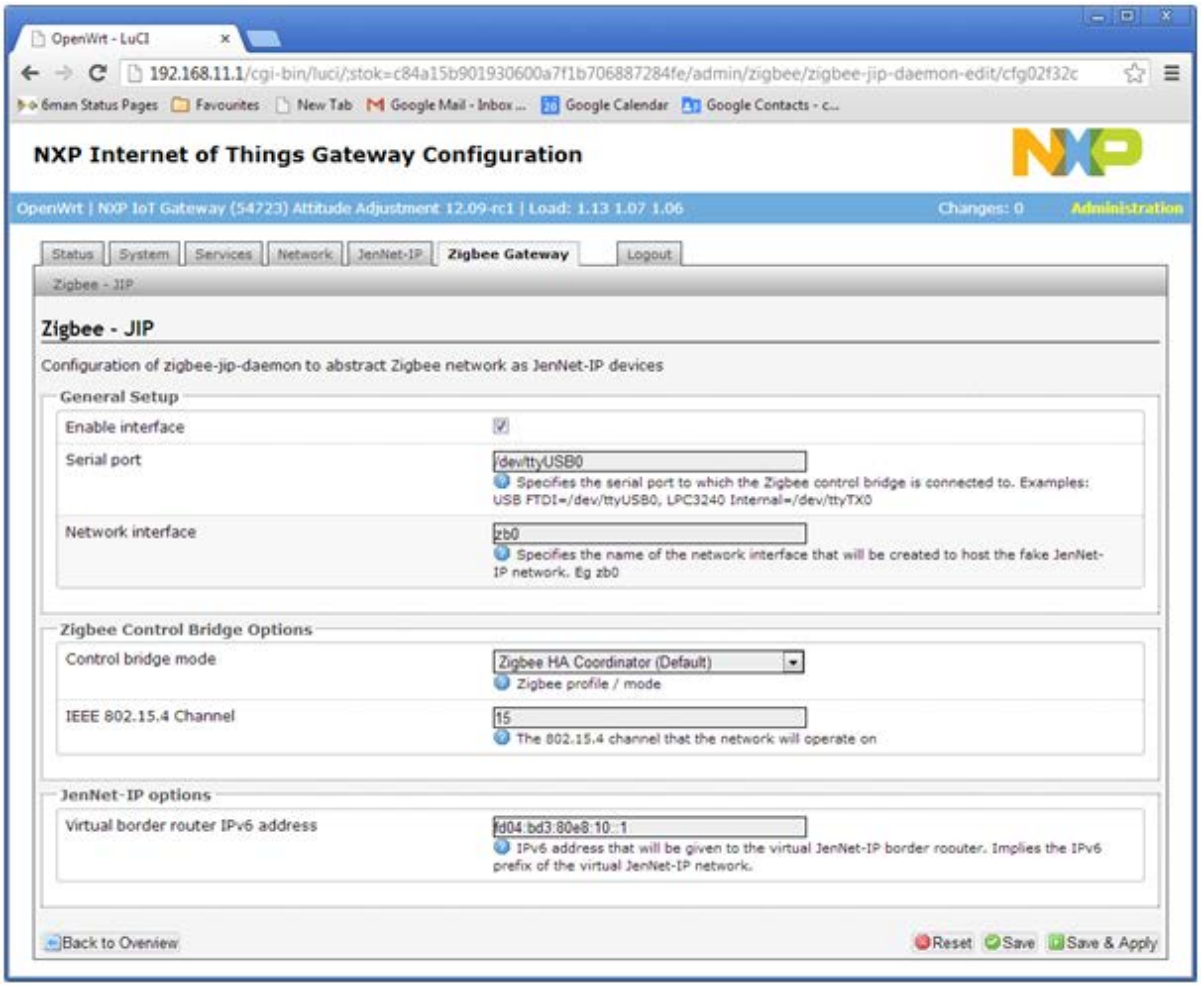
On the “Gateway Configuration” screen select the ZigBee Gateway tab.



2 Select the ZigBee-JIP tab.



From here we can edit the settings of the ZigBee Control Bridge by clicking on “Edit”.



4.4.2 Changing the Operating Mode

In the ZigBee Control Bridge Options section we can select the mode of operation of the Control Bridge.

Click on the drop-down menu and select the required mode (ZigBee HA Coordinator, ZigBee LL Router or the combined ZigBee HA + LL Router).

4.4.3 Changing the ZigBee Channel

The 802.15.4 channel to be used can also be selected. Type the channel number in the “IEEE 802.15.4 Channel” text box.

Note that ZLL devices operate primarily on channels 11, 15, 20 and 25, so if using ZLL devices or a mix of ZLL and ZHA devices in the network, one of the ZLL channels should be selected. ZHA-only networks can use any channel between 11 and 26.

The default setting for the ZigBee network is channel 15. Note also that channels 15, 20 and 25 lie in the gaps between Wi-Fi channels 1, 6 and 11; good practice is to select a 802.15.4 channel well away from the channel selected for the Gateway Wi-Fi network (if enabled or supported) to minimise interference. Selection of a low value for the Wifi tab Transmit Power setting (e.g. 3mW / 5dBm) will also help to reduce interference (see Section 4.1.2 “Setting up a Wi-Fi Connection” on how to change the transmit power setting on hardware which supports Wi-Fi).

4.4.4 Saving the Settings

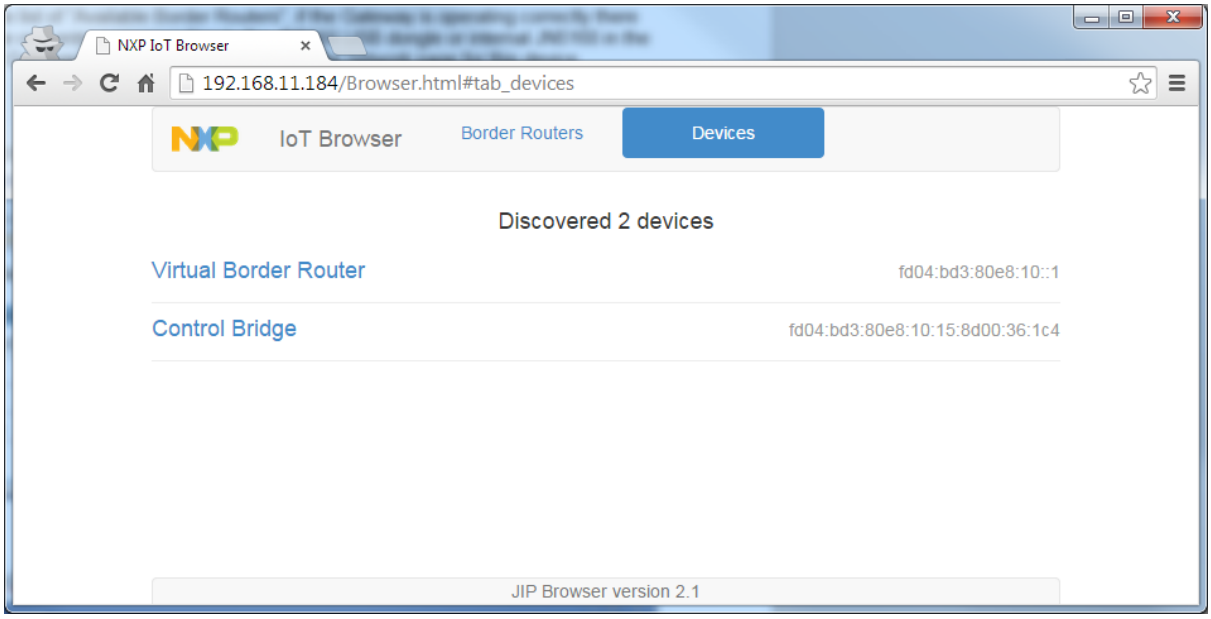
Click on “Save & Apply” to make the changes to the Gateway processor configuration.

The ZigBee Control Bridge stores its settings internally and updates them only when reset by the Host processor of the Gateway/Router. Therefore, we need to reset the Control Bridge to make the above changes take effect.

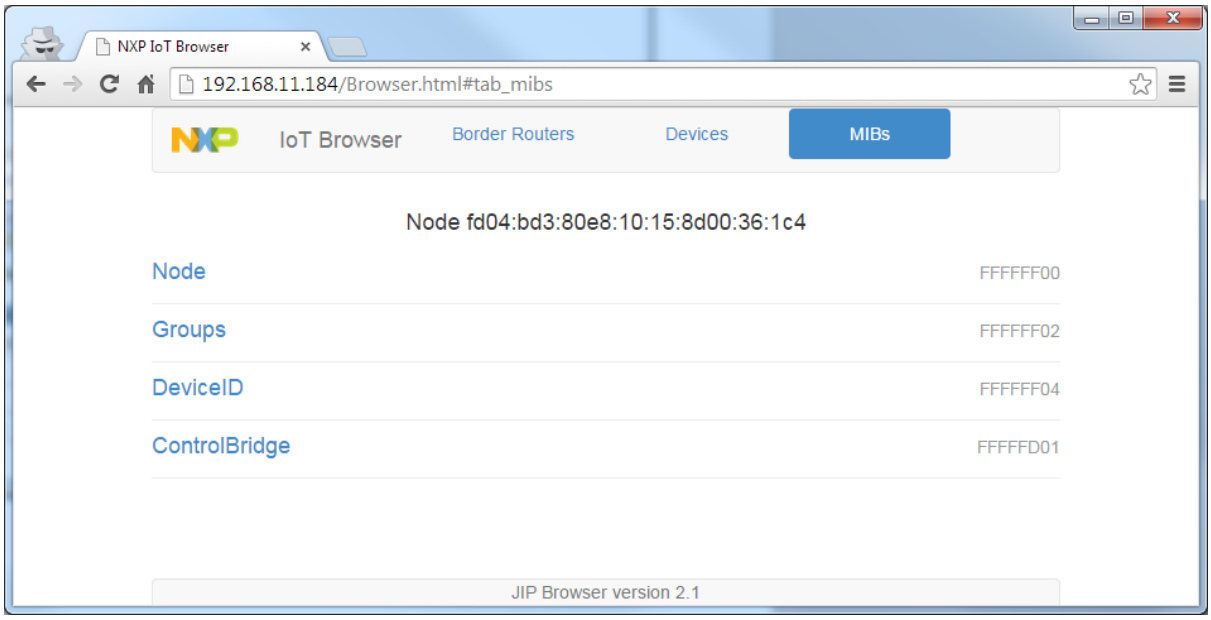
4.4.5 Resetting the Control Bridge to Update Settings

1 Navigate to the landing page of the Gateway at 192.168.11.1(x) and click on the “JIP Browser” link.

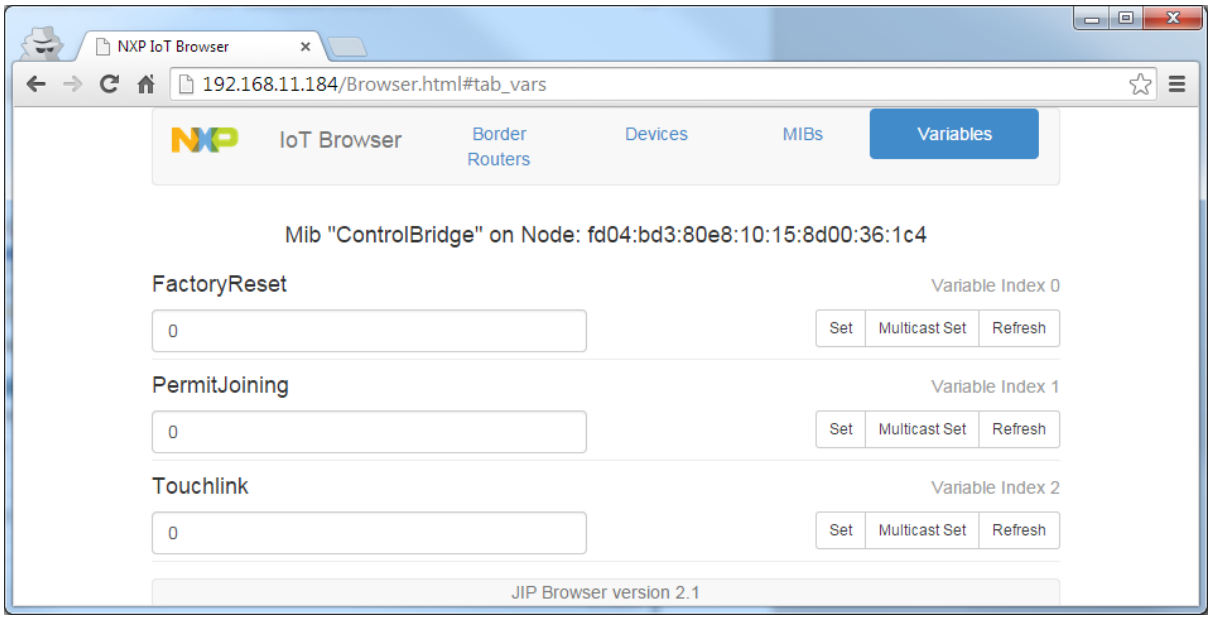
2 Under the list of “Available Border Routers”, if the Gateway is operating correctly there should be one entry corresponding to the JN5168 USB dongle or internal JN5168 in the RD6040 Gateway. Click on this link to display the network page for this device.



3 We need to change settings in the Control Bridge, so click the link.



4 Click the ControlBridge link to reach the configuration page of the Control Bridge.



To reset the Control Bridge, select the “FactoryReset” box and type ‘1’ (any value can be used). Click the “Set” button in the “FactoryReset” line to initiate the reset and update the settings of the Control Bridge. During the reset operation, the LEDs on the USB dongle will flash twice and then remain on to indicate that the reset has completed.

4.5 Setting up the Nodes

The demonstration requires the DR1174 Carrier Boards supplied with the JN516x-EK001 Evaluation Kit to be configured as Lights which can be controlled. Each Carrier Board therefore needs to be fitted with a DR1175 Lighting/Sensor Expansion Board. This is the configuration in which three of the Carrier Boards are supplied in the Evaluation Kit.

Set the jumpers for battery, USB or power supply operation according to how the Carrier boards will be powered during the demonstration. See the JN516x-EK001 Evaluation Kit User Guide (JN-UG-3093) section 1.3.2.1 for details of the jumper settings.

Plug the Lighting/Sensor Expansion Boards into the Carrier Boards as shown in the JN516x-EK001 Evaluation Kit User Guide.

4.5.1 Programming the ZigBee Device Binaries

Depending on which type of device and ZigBee network configuration you are demonstrating, you will need to program each Light with the appropriate binary, either:

- ZigBee Home Automation monochrome dimmable light (**DimmableLight_JN5168_DR1175.bin**) or
- ZigBee Light Link extended color light (**Light_ExtendedColorLight_JN5168_DR1175.bin**).

These binaries are supplied in the **Demo Binaries** directory of the Application Note package. They must be programmed into the devices using a JN51xx Flash programming tool, such as the one provided within BeyondStudio for NXP and described in the *BeyondStudio for NXP Installation and User Guide (JN-UG-3098)*.

5 Commissioning Devices to the ZigBee Network

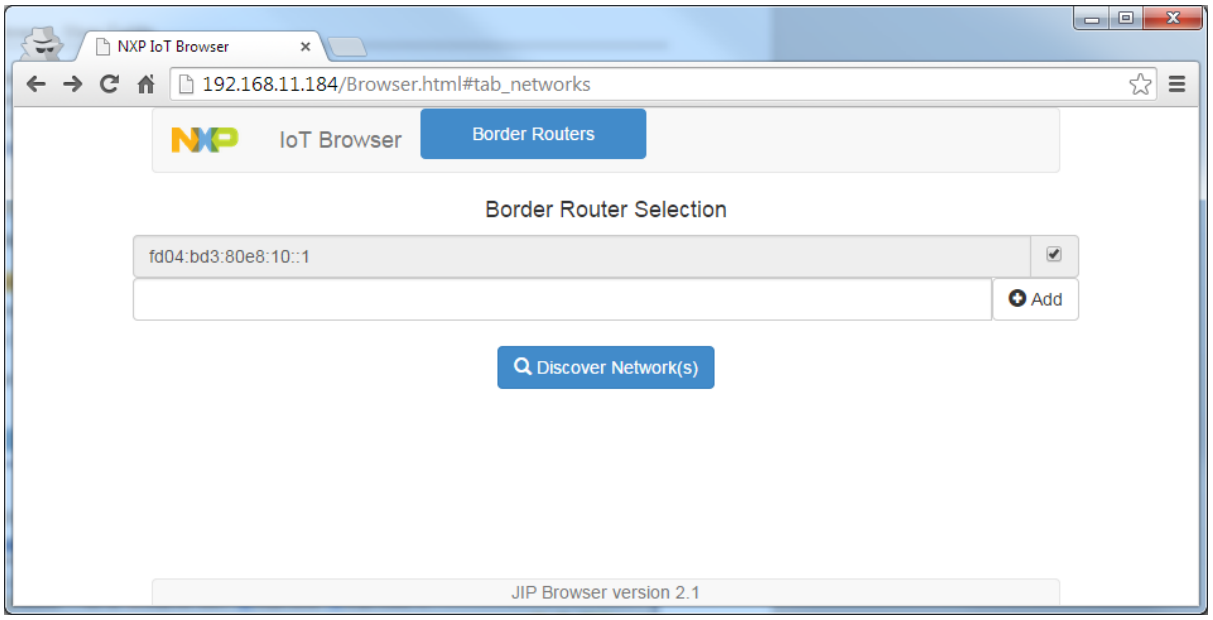
5.1 Classical Join

Classical ZigBee joining is the standard method of joining a device to a ZigBee network, relying on the presence of a ZigBee Coordinator. The Gateway supports classical joining with the “ZigBee HA Coordinator” and “ZigBee HA + LL Router” modes. These modes can be selected as described in the sub-section “Changing the Operating Mode” in Section 4.4.1 “Setting up the ZigBee Network”.

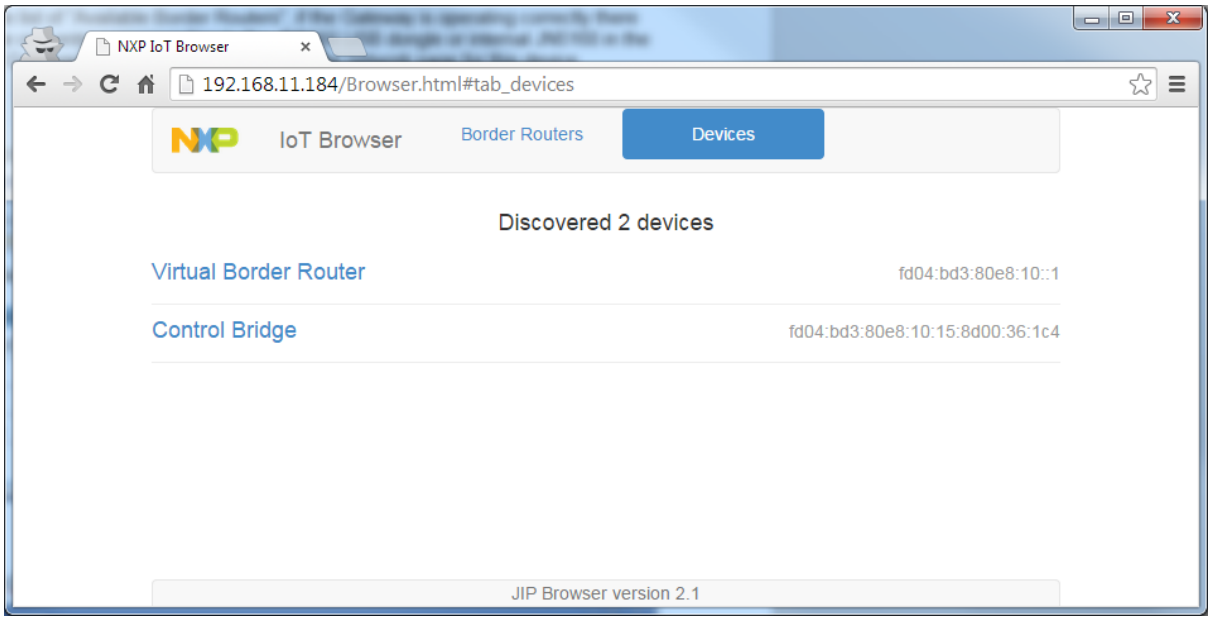
The following instructions assume that the Operating Mode has previously been set to support classical joining. To use the classical joining process to add a device into the ZigBee network, it is necessary to perform the following steps.

First the Control Bridge must be put into the “Permit Joining” state, performed as follows.

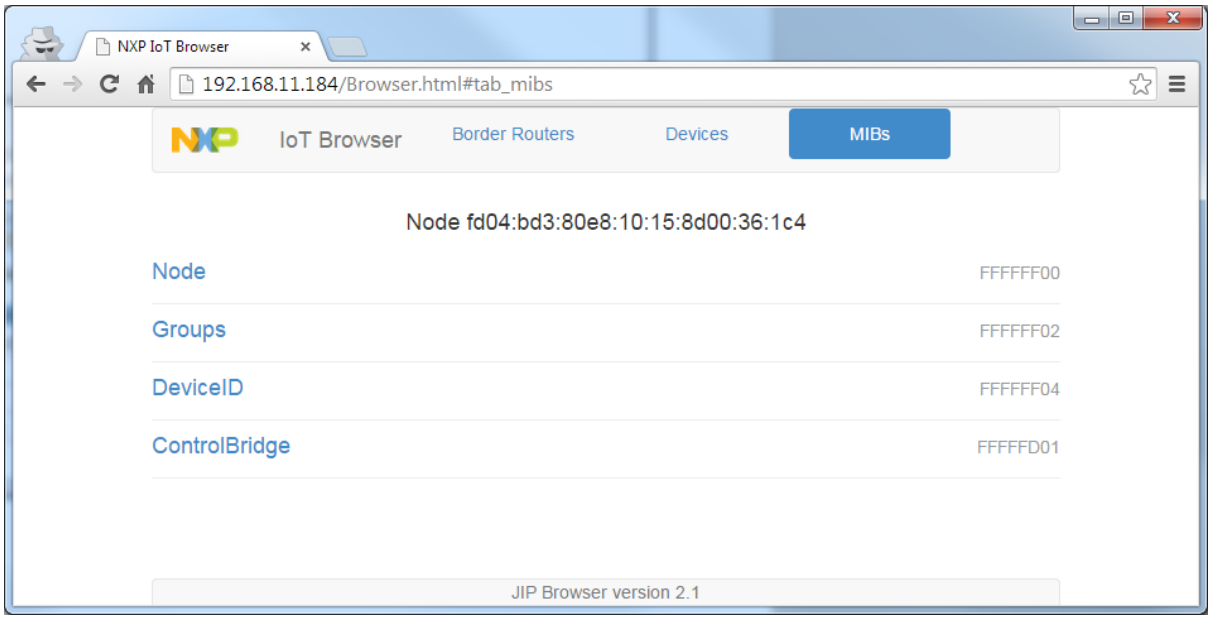
1. Navigate to the landing page of the Gateway at 192.168.11.1(x) and click on the “JIP Browser” link.



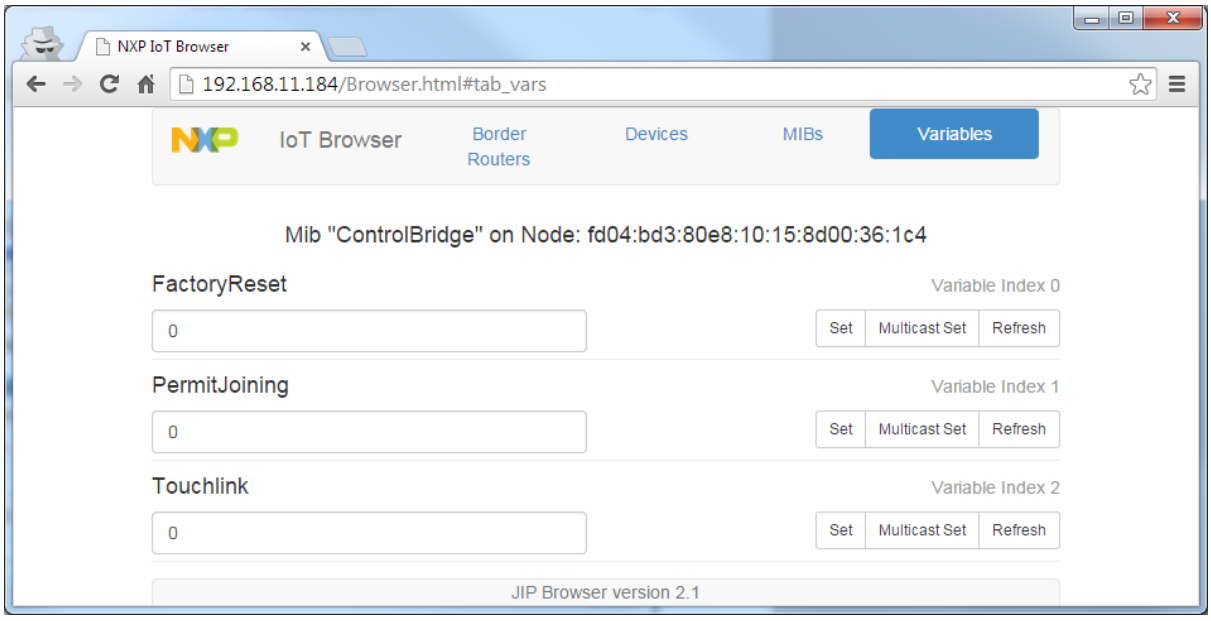
2. Under the list of “Available Border Routers”, if the Gateway is operating correctly there should be one entry corresponding to the USB dongle. Click on this link to display the network page for this device.



3. We need to change settings in the Control Bridge, so click the “Control Bridge” link.



4. Click the “ControlBridge” link to reach the configuration page of the Control Bridge.



5. To enable Permit Joining, select the “PermitJoining” box and type in the number of seconds for which the Gateway should allow devices to join (the joining window). Click the “Set” button in the “PermitJoining“ line to open the joining window. Note that a value of 255 is interpreted as permanently enabling Permit Joining, allowing devices to join at any time without needing to perform this operation again.
6. Apply power to the device to be joined to the network, and perform a “FactoryNew” reset by pressing the button marked DIO8 (next to the JN5168 module on the Carrier Board) together with the RST (Reset) button (on the opposite side of the board). Release the RST button followed by the DIO8 button to perform the operation which removes any previous joining information from the non-volatile memory on the device.

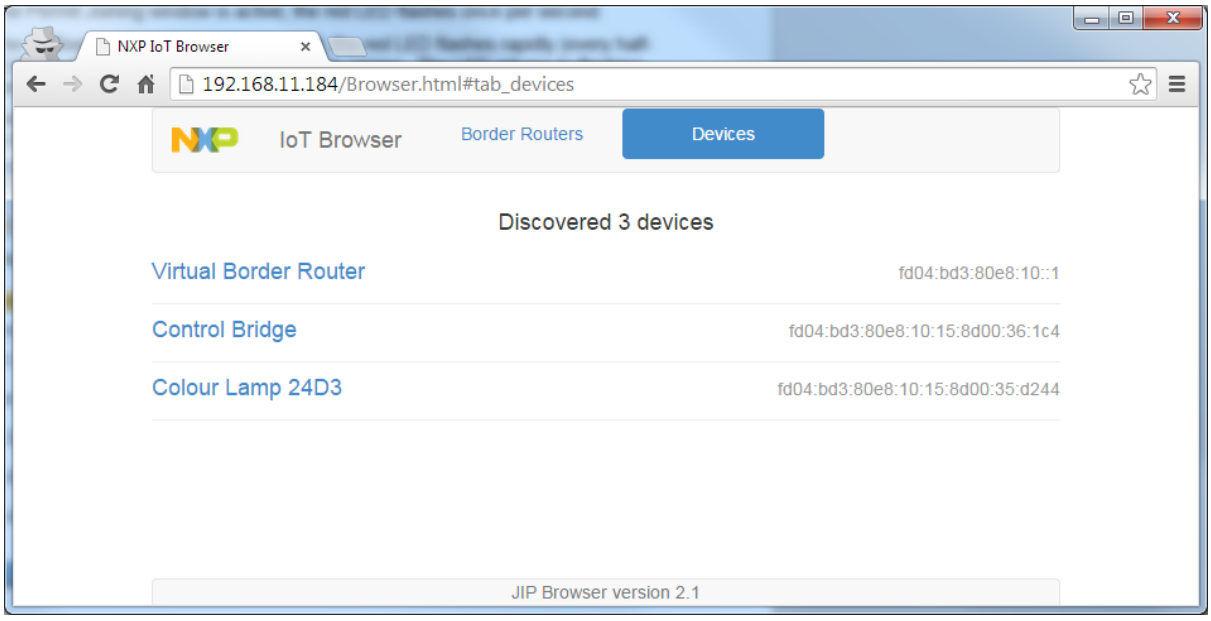
For a Control Bridge programmed in a USB dongle, the LEDs indicate the following states and conditions:

- When a network has been formed by the ZigBee node but is not allowing devices to join, the red and green LEDs are illuminated.
- When the Permit Joining window is active, the red LED on the USB dongle flashes once per second and the green LED is off.
- When the Control Bridge receives a join request, the red and green LEDs flash alternately for 2 secs to indicate that a device is joining. The LEDs returns to flashing once per second while the Permit Joining window is active.

For the RD6040 hardware, the right-most (red) LED indicates the following states and conditions:

- When a network has been formed by the ZigBee node in the Gateway but is not allowing devices to join, the LED is lit.
- When no network has formed the LED is off.
- When the Permit Joining window is active, the red LED flashes once per second.
- When the ZigBee node receives a join request, the red LED flashes rapidly (every half-second) for 2 seconds to indicate that a device is joining. The LED returns to flashing once per second while the Permit Joining window is active.

Once the device has joined the network, its presence can be observed on the Network page of the JenNet-IP Browser.



Here we see that there a new device joined to the network. To differentiate between the individual devices, the device names are annotated with the 16-bit network address that they have been allocated in the network. Note also, that the lower 64 bits of the IPv6 address associated with the node (shown on the right) is the full 64 bit MAC address of the device.

5.2 Touchlink Join

Touchlink is a commissioning process which is supported only in ZigBee Light Link, and is described in the ZigBee Light Link User Guide (JN-UG-3091). To use Touchlink joining to add a device into the ZigBee network, the Gateway must be in either the "ZigBee LL Router" or "ZigBee HA+LL Router" mode. These modes can be selected as described in Section 4.4.2 "Changing the Operating Mode".

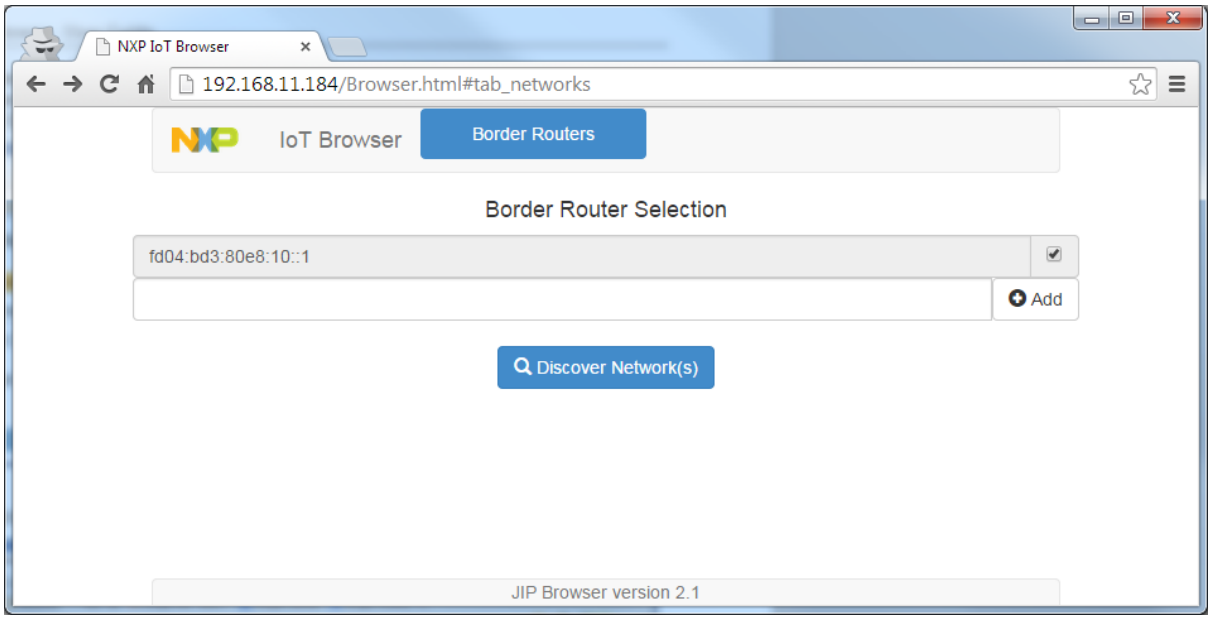
The devices to be added must be ZLL devices. Make sure that the ZLL binary has been installed in the devices to be used (for example the DR1174 Carrier Boards from the Evaluation Kit). If necessary, reprogram the boards using the procedure described in Section 4.5.1 "Programming the ZigBee Device Binaries".

The Touchlink process relies on the device to be added to the network being within a few centimetres of the Touchlink source (in this case the USB dongle or internal JN5168). It will be easier to bring the device close to the Gateway if it is powered by batteries rather than an external power source such as a PSU or USB connection to a PC. If it is intended to power the devices by batteries, refer to JN516x-EK001 Evaluation Kit User Guide (JN-UG-3093) for details of the jumper settings.

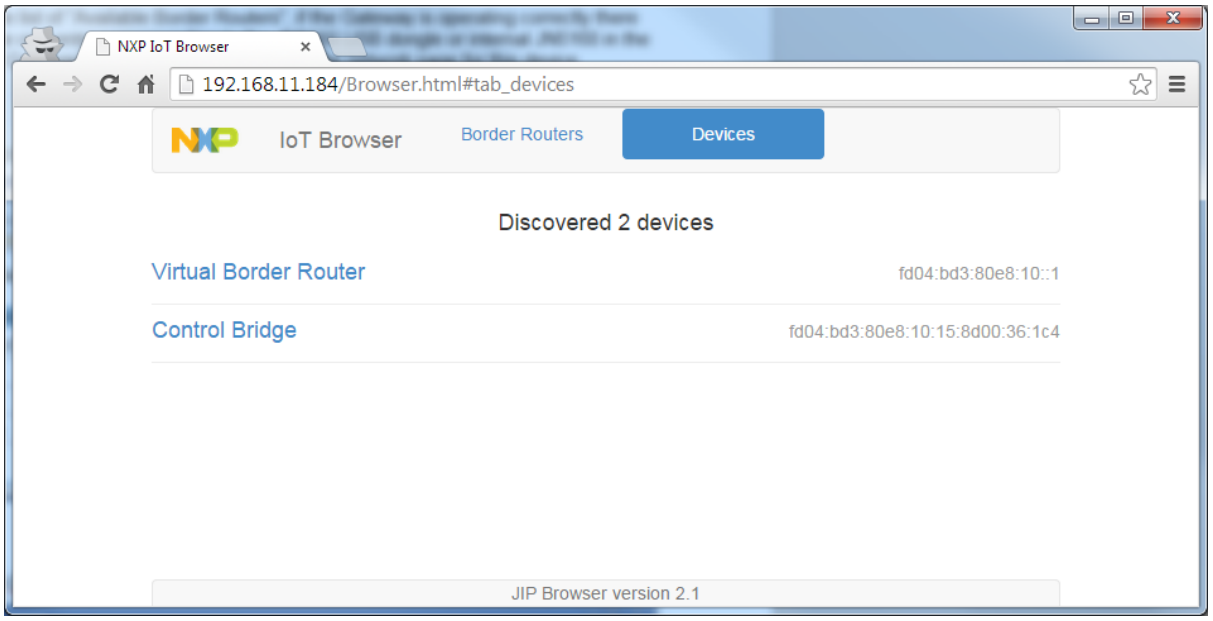
The following instructions assume that the Operating Mode has previously been set to support Touchlink joining.

To initiate Touchlink joining, use the following procedure.

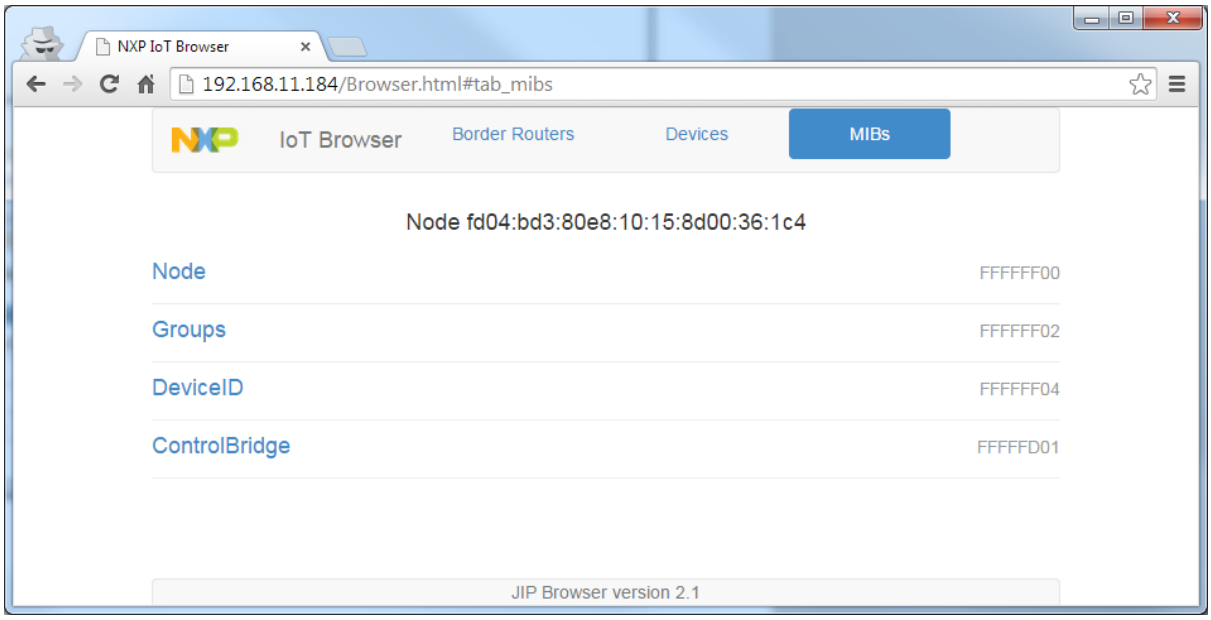
1. Navigate to the landing page of the Gateway at 192.168.11.1(x) and click on the “JIP Browser” link.



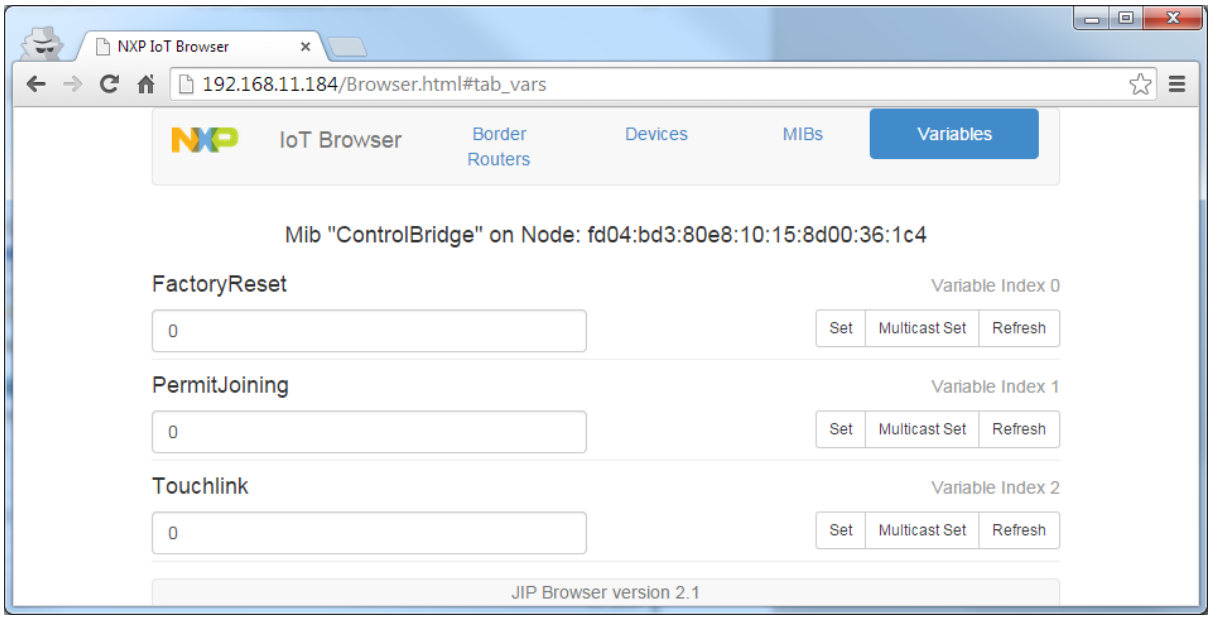
2. Under the list of “Available Border Routers”, if the Gateway is operating correctly there should be one entry corresponding to the USB dongle or internal JN5168. Click on this link to display the network page for this device.



3. It is necessary to change settings in the Control Bridge; click the ”Control Bridge” link.



4. Click the “ControlBridge” link to reach the configuration page of the Control Bridge.



5. Touchlink can be performed at any time on a ZLL device, and uses proximity as a means of selecting the device to be joined to the network. During a Touchlink operation, the transmit power of the initiator (in this case the Gateway) is reduced so that the Touchlink process will only operate over a short distance.

   At this point, bring the device to be Touchlinked within a few centimetres of the Gateway dongle.

6. Initiate Touchlink on the Gateway by setting the Touchlink field to a non-zero value. Select the Touchlink box and type ‘1’. Click the **Set** button in the entry to initiate the Touchlink operation on the Gateway.

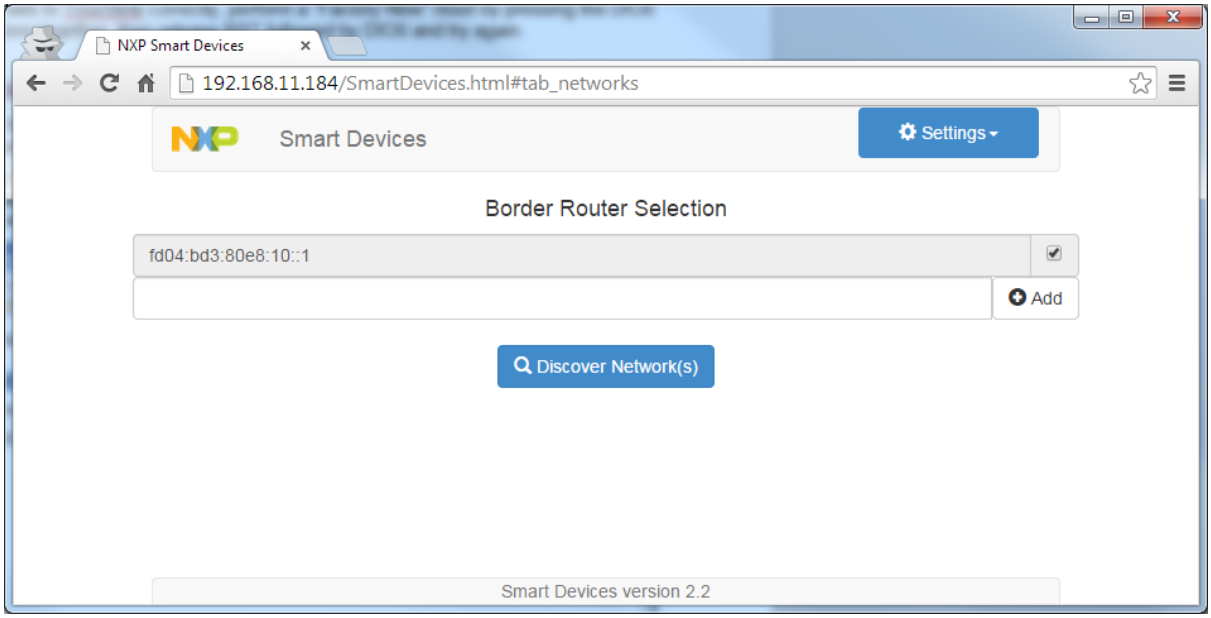
If the Touchlink operation is successful, the device will perform an “identify” action to show it has joined the network. On the ZLL Extended Color Light, this is indicated by the LED turning red and then back to white. Now the device has joined the network, its presence can be observed on the Network page of the JenNet-IP Browser.

If the device fails to Touchlink correctly, perform a “Factory New” reset by pressing the DIO8 and RST buttons together, then release RST followed by DIO8 and try again.

6 Controlling ZigBee Devices

After devices have been successfully joined to the network, we can attempt to control them. This will be done through the SmartDevices web pages.

1. This is reached by clicking the “JIP SmartDevices” link on the landing page, or navigating directly to http://192.168.11.1(x)/SmartDevices.html. The initial page looks very similar to the JenNet-IP Browser:



2. Initiate discovery of the the networks by clicking “Discover Network(s)”. This automatically brings up the Global Control page; however, to control individual devices it is necessary to click on the “Individual Control” tab.

Entries are shown corresponding to the devices in the network.

Each entry allows the light to be switched on and off by clicking the “On” and “Off” buttons.

The brightness of the light can be set by clicking within “Level” strip. The brightness level increases the further to the right that the strip is clicked, with maximum brightness at the right-hand end.

If the light is switched off and then on again, it returns to its previous brightness setting.

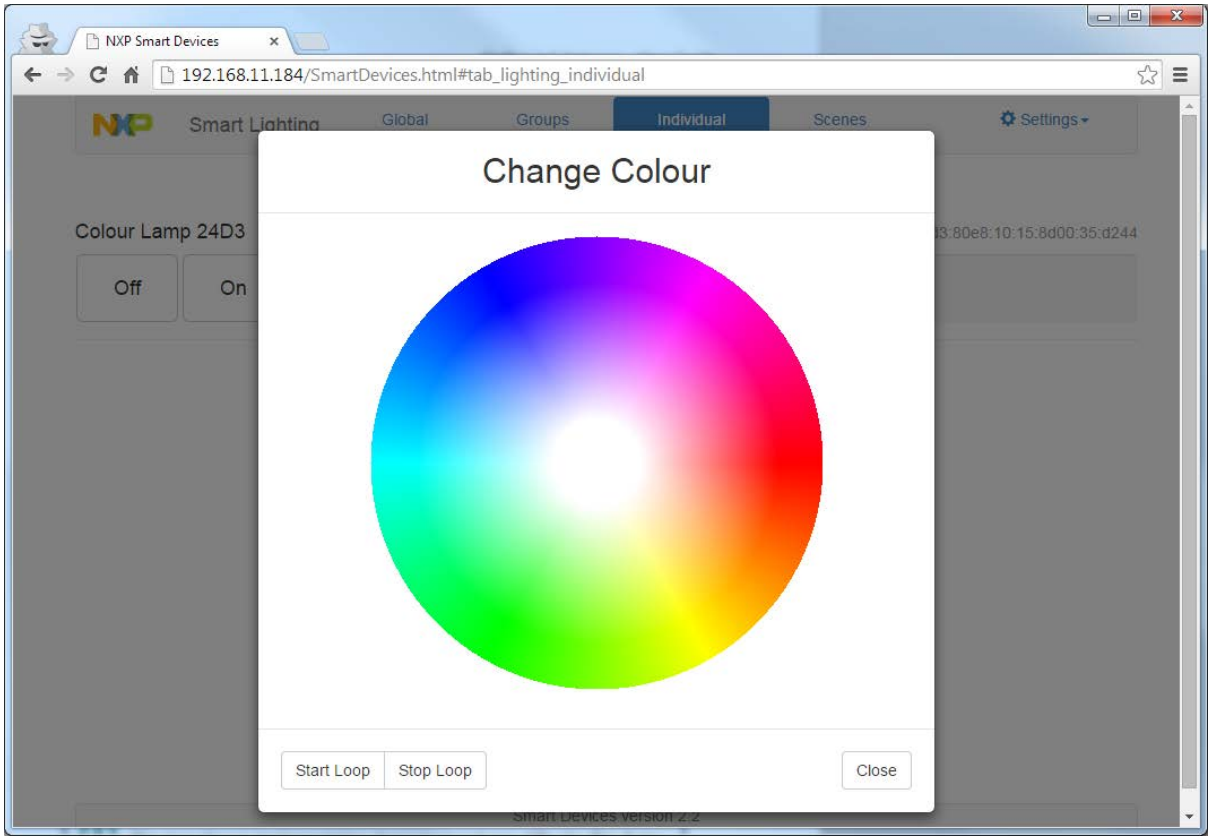
If the light is turned off and then the brightness strip is clicked, the light turns on to that brightness.

The devices in this network are all ZLL Extended Color Lights, denoted by their name and also the colour wheel and colour temperature buttons. The colour of a ZLL Extended Color Light can be adjusted to any supported hue / saturation. The colour temperature of a ZLL Extended Color Light can be adjusted to any supported temperature. If the device does not support these functions, the corresponding buttons will not appear in “individual” control, but will always appear in global and group control. Using these controls for devices that do not support the commands will have no effect.

6.1 Colour Control

Click on the colour wheel button of the device whose colour is to be changed.

The following display appears, consisting of an enlarged colour wheel:



The colour wheel allows the control of two parameters, hue and saturation. Hue is essentially the colour required, while saturation determines how intense the colour will be. Hue is controlled by moving around the colour wheel, while saturation is set along the radius; as can be seen, colours become more intense (i.e. saturated) the closer to the circumference of the wheel they are. White is at the centre of the wheel.

Clicking on a position within the wheel will adjust the light to the selected colour. Selecting one colour followed by another will initiate a transition from the original colour to the new one. The transition is made by traversing the colour wheel in a clockwise direction; this means that if red is the initial colour and then blue is selected, the colour will change in the order red-yellow-green-cyan-blue during the transition.

This transition is implementation-dependent and may differ for ZLL Color lights from other manufacturers.

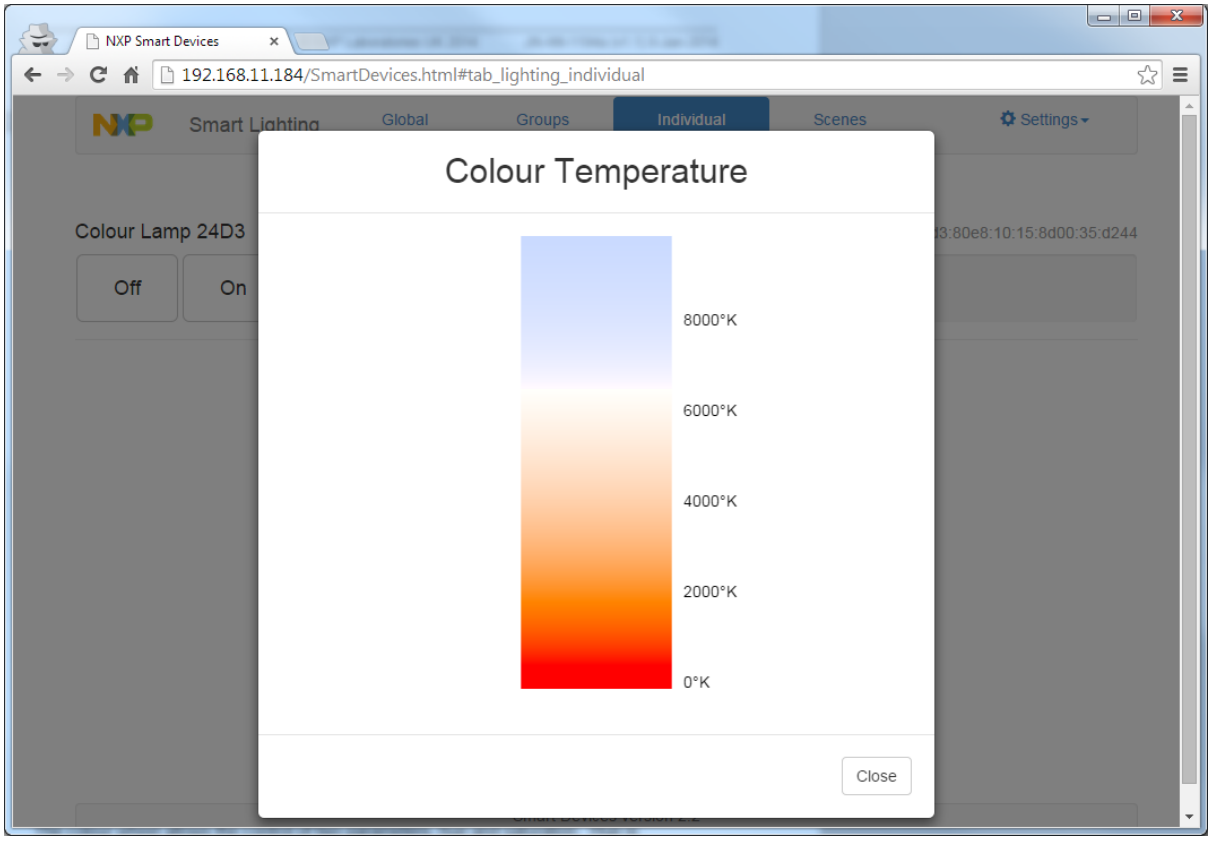
ZLL Extended Color lights also support “color loop” which means the device will cycle through colors around the hue circle in a clockwise direction. Clicking on the “Start loop” button will begin the loop, and “Stop loop” terminate it.

To terminate colour adjustment, click on the “Close” button.

6.2 Colour Temperature Control

Click on the colour temperature button of the device whose colour temperature is to be changed.

The following display appears, consisting of an enlarged colour temperature scale:



Clicking on a position within the color temperature scale will adjust the light to the selected colour temperature. Selecting one colour temperature followed by another will initiate a transition from the original colour temperature to the new one. If a color temperature is selected which is outside of the device's capabilities, the light will move to the nearest color temperature that it is capable of.

> This color temperature behaviour is implementation-dependent and may differ for ZLL Color lights from other manufacturers.

To terminate colour temperature adjustment, click on the "Close" button.

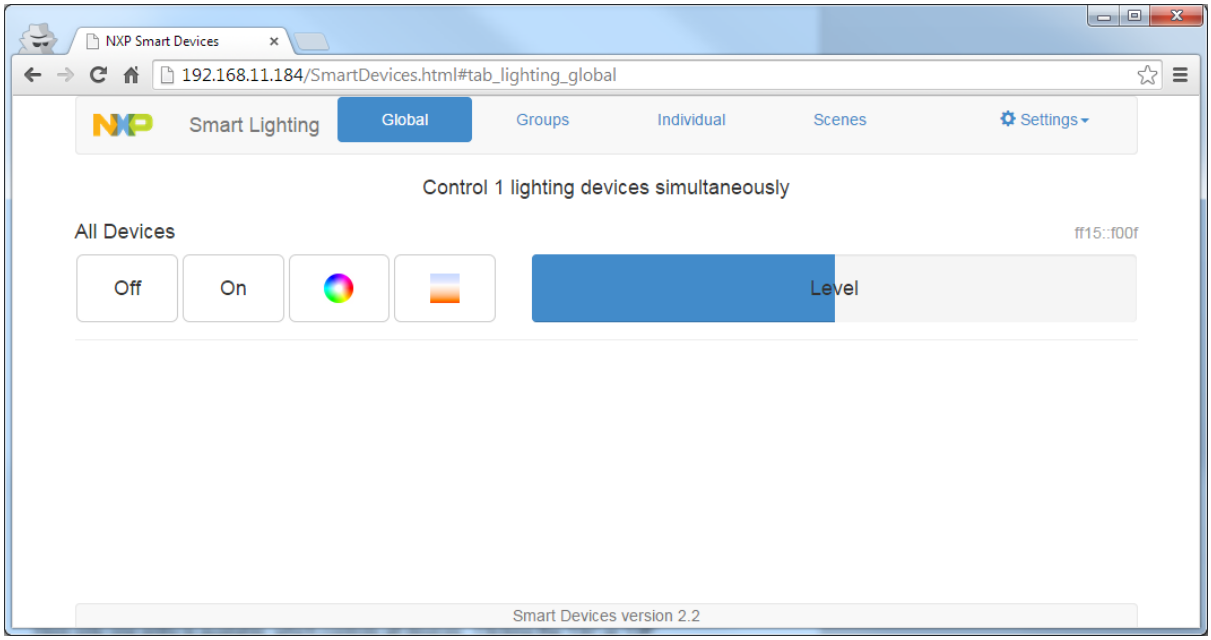
7 Controlling Groups of Devices

The demonstrator allows devices to be assigned to groups, the members of which can be controlled together. This is to allow all devices in a particular logical group to be controlled by the same command; a group might be set up to control all the lights in the living room of the house, or perhaps all colour lights in a particular area.

7.1 Global Group

When a light joins the network it is automatically put into the Global group.

The Global group is controlled from the “Global Control” page in the Smart Devices page. To enter, click the “Global Control” button



Here only one entry is available, which controls all devices. Clicking the “On” or “Off” buttons switches all the lights on or off and clicking on the brightness control strip results in all the lights moving to that level.

Clicking the brightness strip when all the lights are off switches them all on to that level.

Switching the lights off and then on again returns them all to the previous brightness setting.

To control the colour or colour temperature of any capable devices present in the network, there are also colour wheel and color temperature buttons.

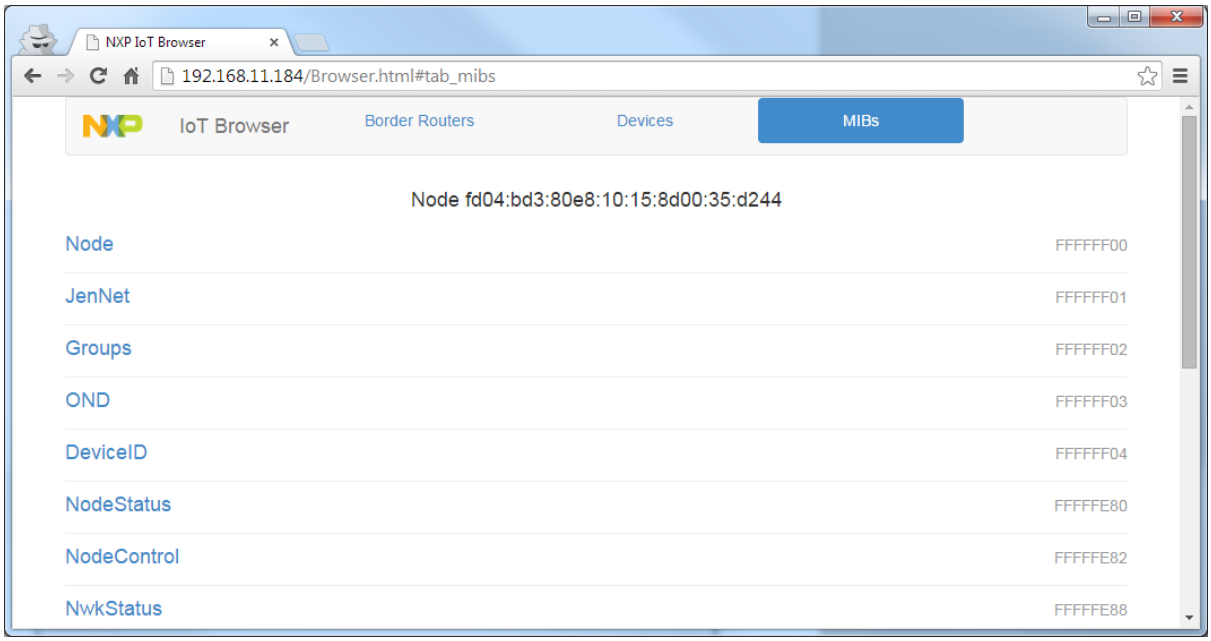
7.2 Other Groups

In addition to the Global group, two others have been defined called Hall and Lounge. It is not currently possible to create further groups in the Smart Devices browser pages.

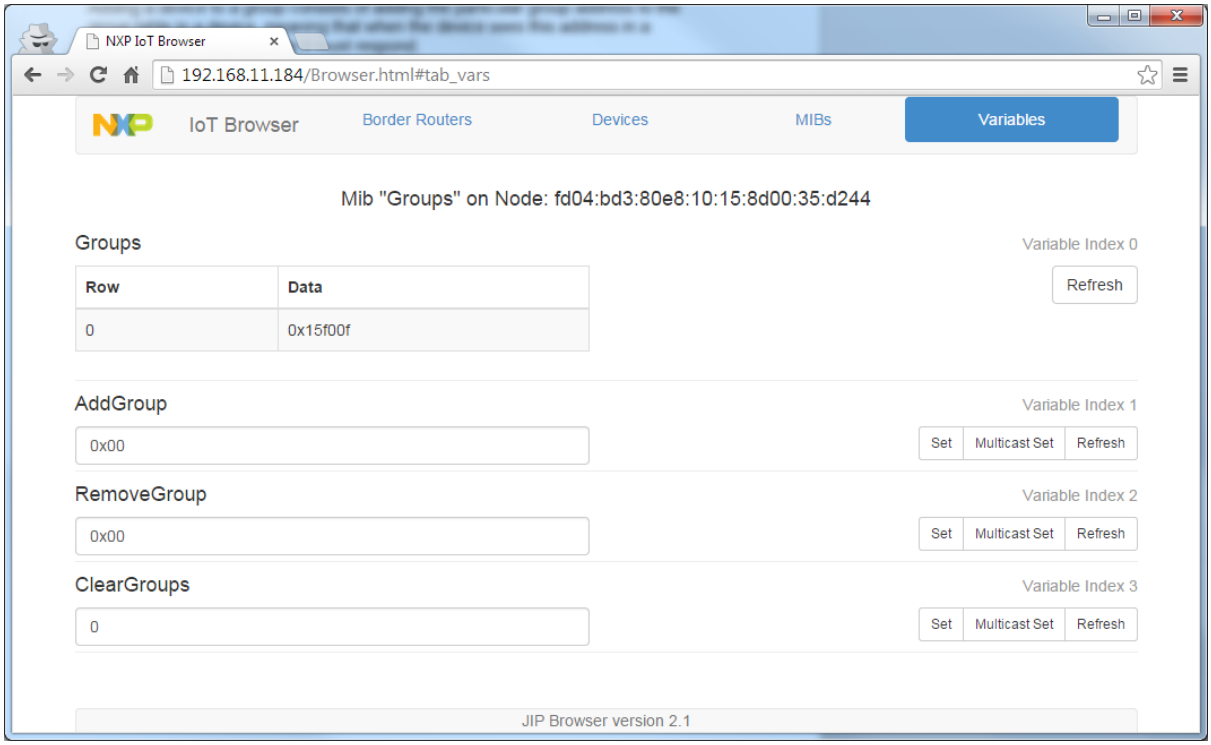
7.3 Adding a Device to a Group

1. To add a device to a group, we need to return to the JenNet-IP Browser pages at http://192.168.11.1(x)/Browser.html .
2. Select the Network tab to show the list of devices in the network.

3. Click on the device to be added to the group. This will bring up a list of MIBs, most of which are used in JenNet-IP systems and are not used by ZigBee devices.



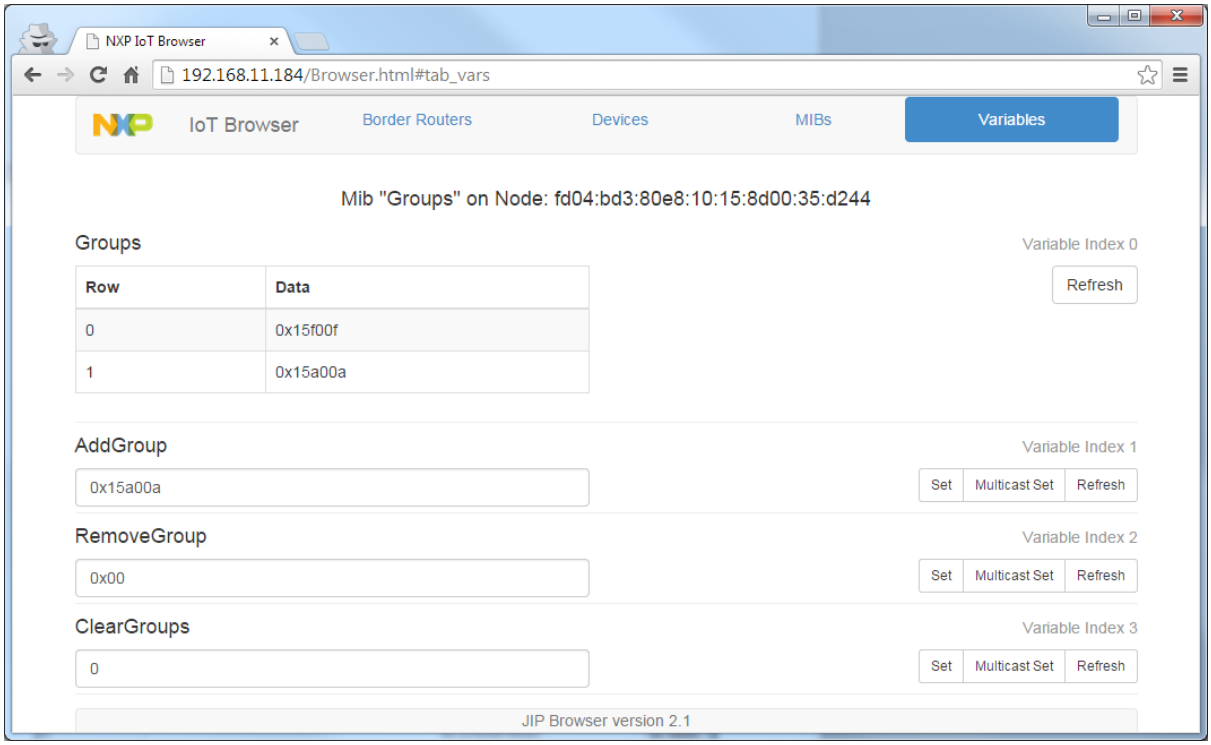
4. Click on the “Groups” entry. This takes us to the Group control page for this device. Adding a device to a group consists of adding the particular group address to the group table in a device, meaning that when the device sees this address in a command message it knows it must respond.



The Groups table shows one entry in row 0, 0x15f00f. This indicates that the first entry in the group table (Index 0) contains the group address 0x15f00f, which is the address of the “All Devices” or Global group.

The Hall group address is 0x15a00a and the Lounge group address is 0x15b00b.

5. To add the device to the Hall group, select the “AddGroup” box and enter the value 0x15a00a and click “Set”.
6. To check that the group address has been added to the group table, click “Refresh” on the Groups entry. There should now be two entries, the Global address in row 0 and the Hall address in row 1 of the table.

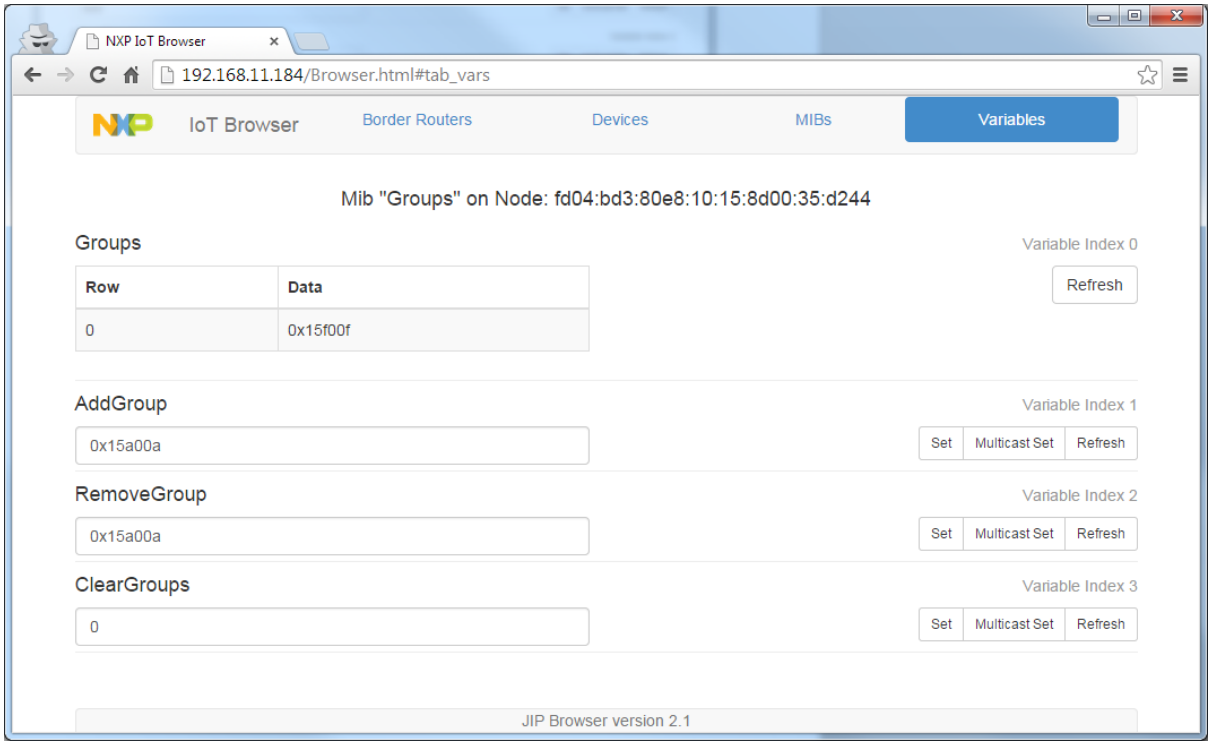


7.4 Controlling the Group

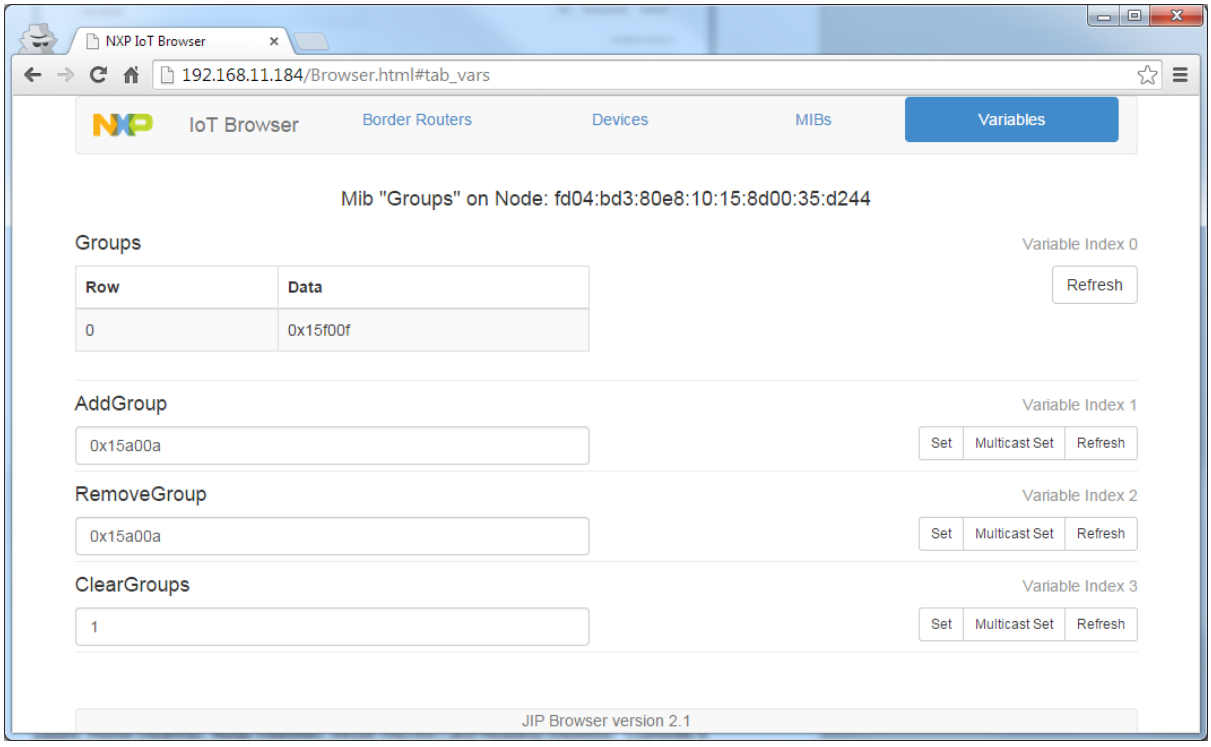
On the SmartDevices “Group Control” page, switch the device on and off by clicking the “On” and “Off” controls of the Hall group. Adjust the brightness of the device using the Hall group brightness control. Notice that it is unaffected when the Lounge group controls are used.

7.5 Removing a Device from a Group

1 In the “Groups” MIB page for the device in the Browser web pages, type the address of the group to be removed in the “RemoveGroup” text box, (e.g. 0x15a00a) and click “Set”. Check that the operation is successful by clicking “Refresh” on the Groups entry, which should leave only the Global group entry displayed



2 All entries (except the global group) can be removed from the device Group table by entering any value in “ClearGroups” and clicking “Set”



8 Using Scenes

8.1 What is a scene?

Scenes are a refinement of the idea of groups. Groups allow the use of a single command to control multiple devices (which are members of a particular group) and set a common parameter to the same value. Scenes enhance group control by allowing the common parameters in a group of devices to be set to a different value per device, which are then stored related to a scene identifier. At some time in the future these values can be recalled across all the devices by issuing a go-to-scene command containing the scene identifier.

As an example, consider a living room where, if you are watching a movie, you want to dim the lights around the TV but leave one at half brightness next to the door. You can define a scene for watching movies. When this is selected, the lights are set to the values determined by the scene. Each light remembers its brightness value for a particular scene identifier. Scenes are not limited to controlling lights – part of the movie scene might be to lower a projection screen.

In the demonstration, there are four pre-defined scenes available in the Smart Devices web pages: Home (0xa00a), Away (0xb00b), Movie (0xc00c) and Reading (0xd00d). Currently it is not possible to create further scenes in this release of the demonstration.

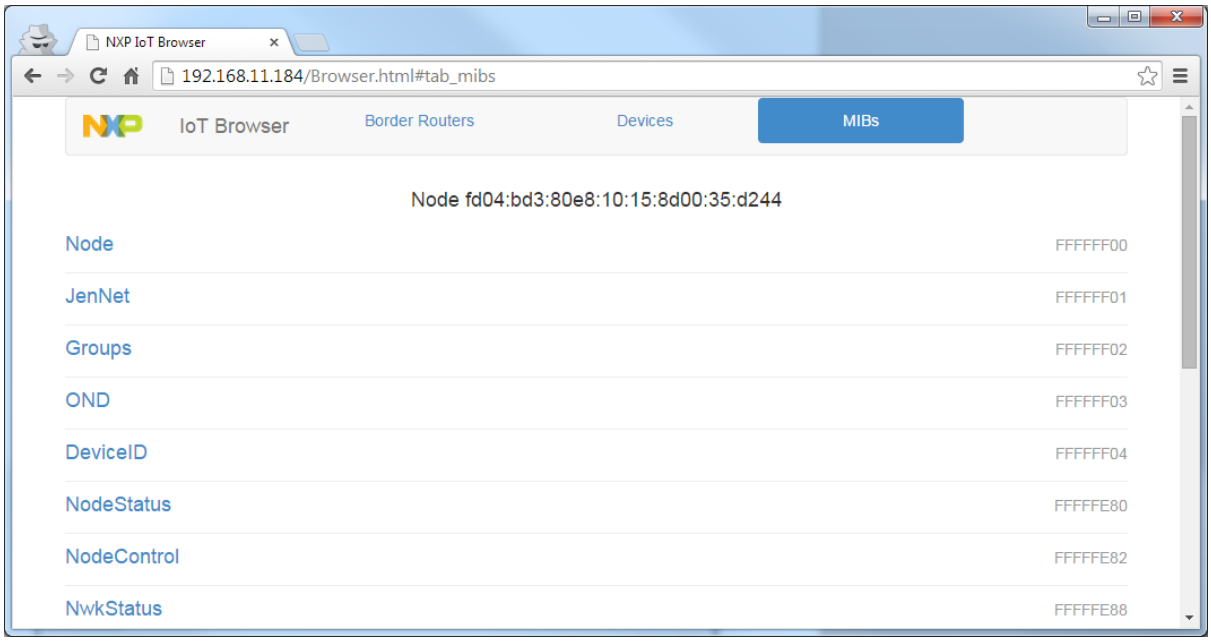
Scenes operate by broadcasting the “Goto scene” command to devices subscribed to a group address. In ZigBee, scenes may be defined for any group of devices (e.g. Lounge, Hall etc.). The scenes defined in the demonstration operate on the All group (0x15f00f). In any scene implementation, the devices which are part of that scene must be members of the group used by the scene. In the demonstration, this means that devices must remain members of the All group (into which they are added automatically at the time of joining the network). If group membership of a device is changed, either by deleting the All group from its group table or clearing the group table, scenes will not work. If the All group is removed from the group table of a device, scenes which were previously working can be re-enabled by restoring the All group into the group table.

8.2 Adding a Device to a Scene

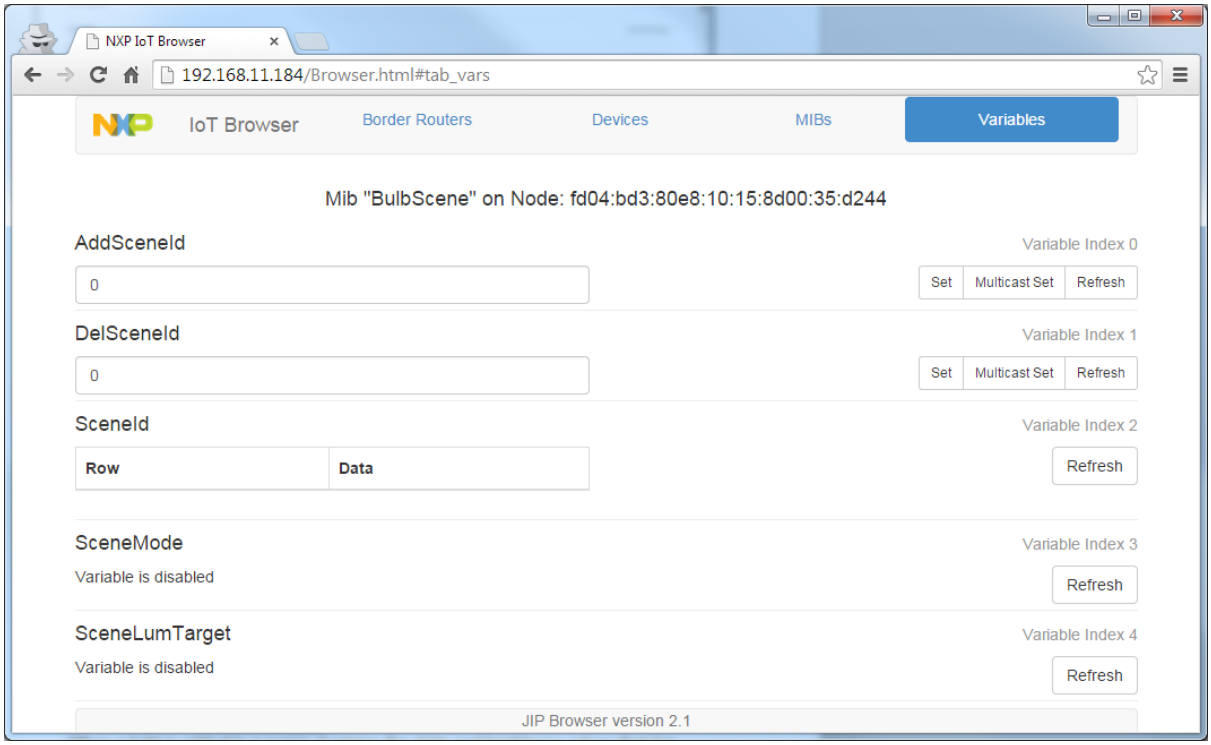
1 In order to add a device to a scene, we need to return to the JenNet-IP Browser pages at http://192.168.11.1(x)/Browser.html

2 Select the Network tab to show the list of devices in the network.

3 Click on the device to be added to the scene. This will display a list of MIBs, most of which are used in JenNet-IP systems and have no effect for ZigBee devices.



4 Select the “BulbScene” entry:

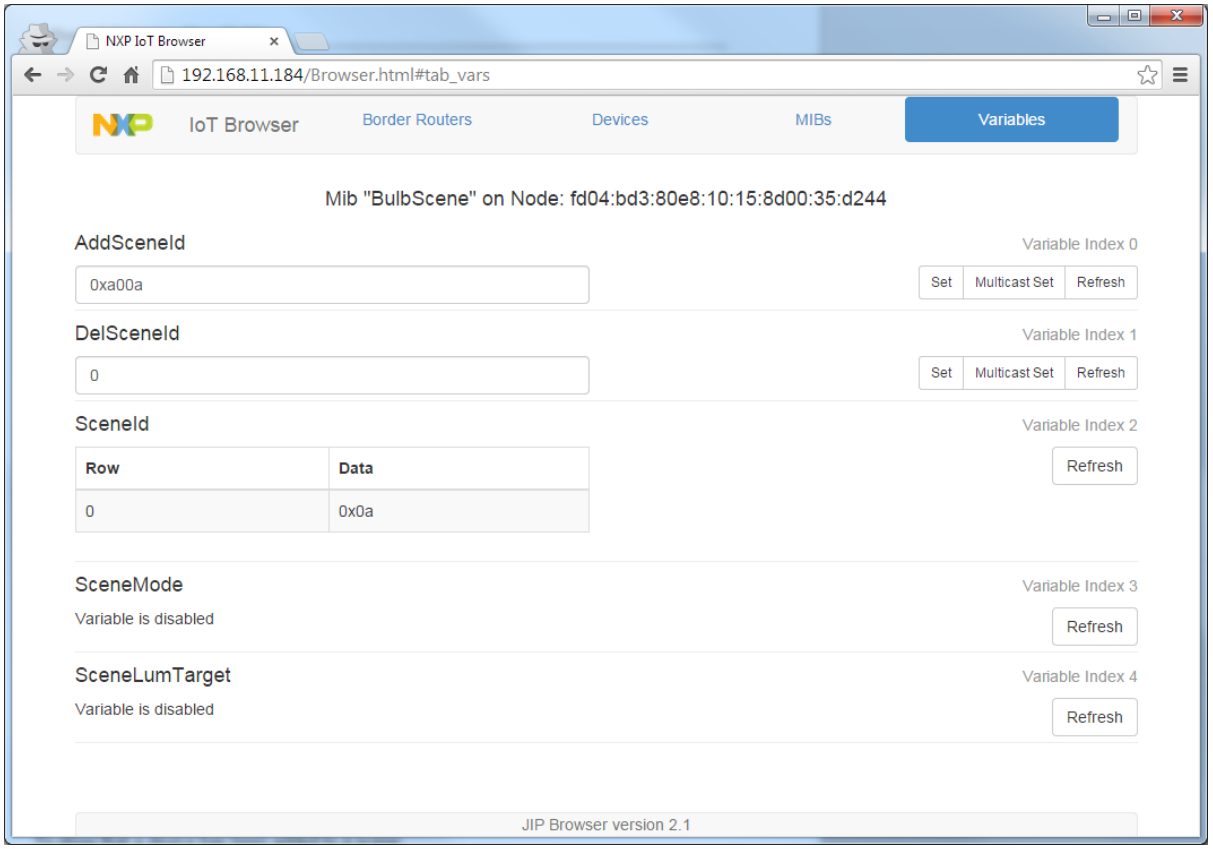


When a light is added to a scene, it retains the state and brightness values that it is currently set with. When the scene is replayed, it will use these values to return to the scene state.

6 To add a device to a scene, we add use “AddSceneId”. For example, to add the settings of this light to the Home scene, we add the Home sceneId 0xa00a to the scene table:

a) In the “AddSceneId” text box enter the sceneId 0xa00a and click “Set”.

b) To show that it has been added to the scene table of the device, click “Refresh” on the “SceneId” entry.



The SceneId table now contains the value 0x0a in row 0.

8.3 Controlling Devices using Scenes

To show that a device has been added to a scene:

1 Place all the devices in the network into a particular state using the Global Control page controls in the Smart Devices web pages.

2 Navigate to the “Scene Control” page and click the “Home” scene control. Observe that the device (which was added to the Home scene above) changes state.

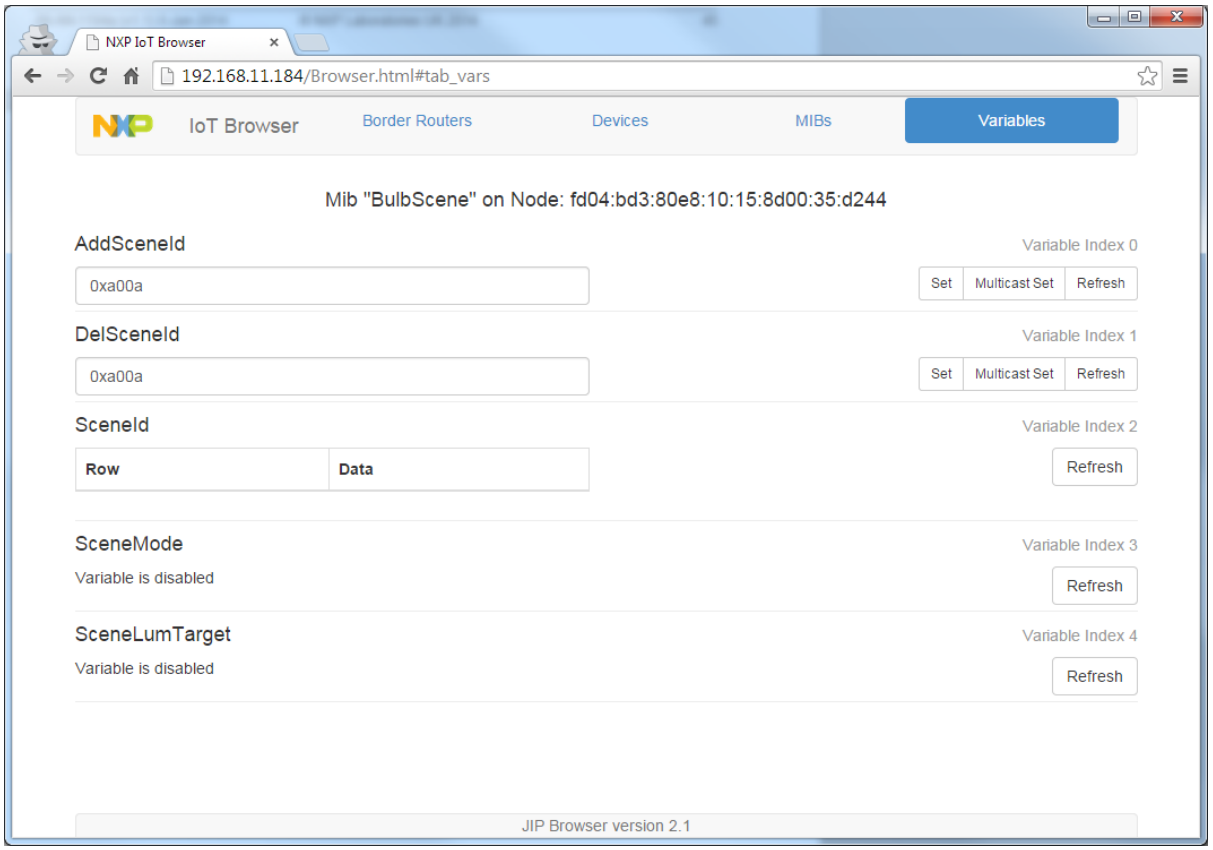
8.4 Removing a Device from a Scene

A device can be removed from a scene so that it no longer responds to the particular go-to-scene command in the following way:

1 Using the device which was previously added to the Home scene, navigate to the “BulbScene” MIB page for the device in the Browser web pages.

2 Type the SceneId of the scene to be removed in the “DelSceneId” text box, (e.g. 0xa00a) and click “Set”.

3 Check that the operation is successful by clicking “Refresh” on the SceneId entry, which should result in an empty table.



Appendix A: Modifying an Existing ZigBee IoT Gateway Configuration

This appendix refers to the appearance of the Gateway web pages after a Gateway has been upgraded to the ZigBee IoT Gateway binary. These are slightly different to those found in a JenNet-IP Router as supplied in the JN5168-EK001 Evaluation Kit.

To program a new version of the ZigBee Gateway (ZGW) binary into the Flash memory of the Linksys router or RD6040 IoT Gateway, perform the following actions:

For the Linksys router:

1 Plug in the Linksys power supply and apply power to the router.

2 Plug an Ethernet cable into one of the Router ports marked 1 to 4.

3 Connect the other end of the Ethernet cable to a laptop computer or PC.

For the RD6040 IoT Gateway:

1 Plug in the RD6040 power supply and apply power to the Gateway.

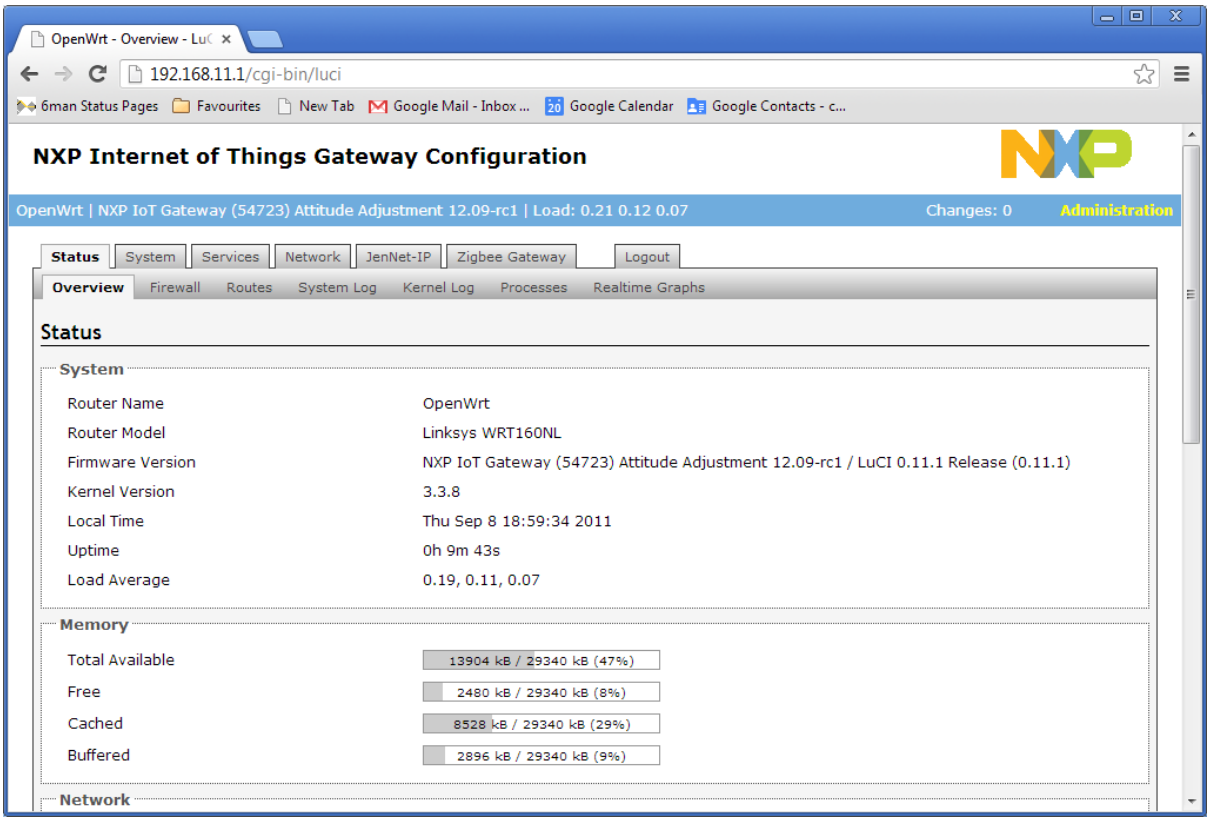
2 Plug an Ethernet cable into one of the Router ports marked 1 to 4.

3 Connect the other end of the Ethernet cable to a Router or PC containing a DHCP server.

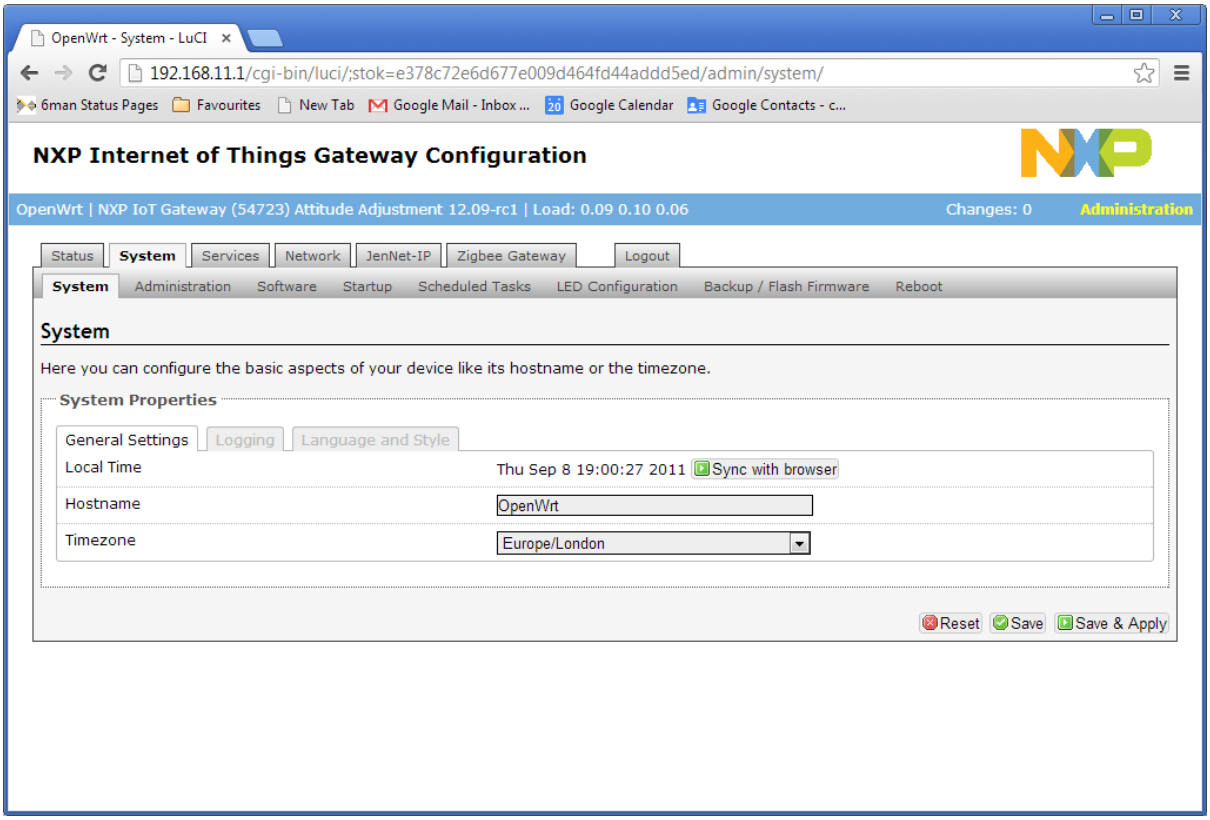
Determine the IP address (192.168.11.x) allocated for the RD6040 Gateway by the DHCP server (see Section 4.3.2 “Finding the IP Address of the RD6040 Gateway” for details of this process when connected to an OpenWRT-based router such as the Linksys supplied in the JN5168-EK001 kit)

4 In a web browser, navigate to 192.168.11.1(x). You will see the following screen (the “landing screen”). Click on the “Gateway Configuration Interface” link.

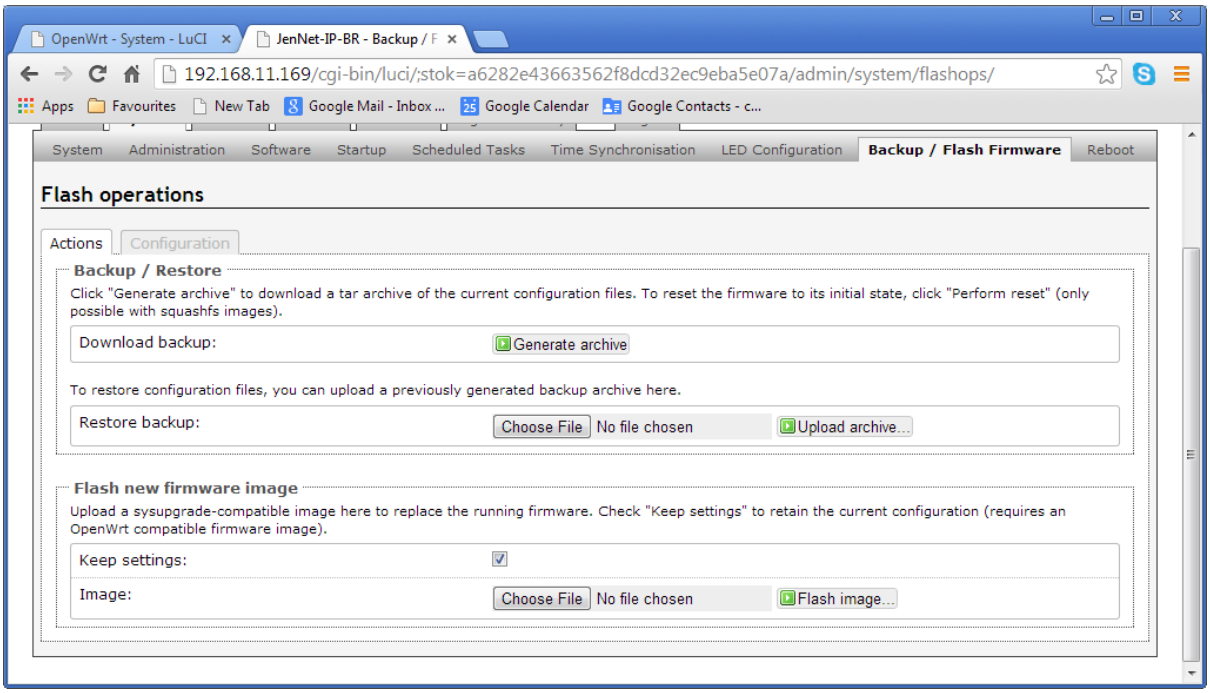
5 Login to the Gateway using the username “root” and the password “snap”. You will see the “Gateway Configuration” screen.



6 Select (click on) the “System” tab.



7 Select “Backup/Flash Firmware”.

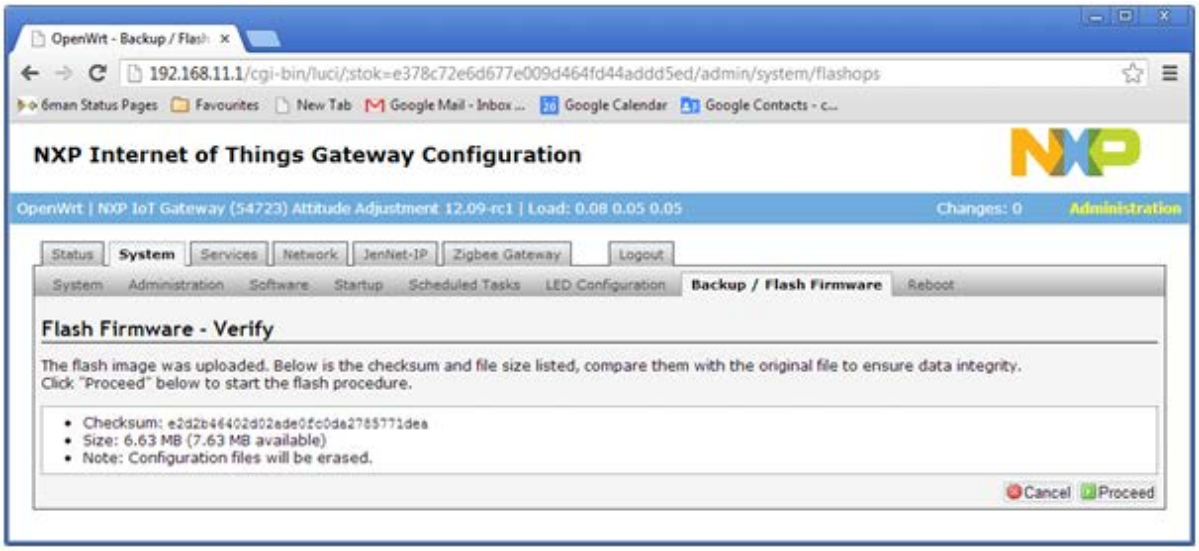


8 In the section “Flash new firmware image”, if you are simply updating the Host firmware to a new version and you require the settings for the Gateway to be maintained, such as the ZigBee channel, ensure the “Keep settings” check-box is ticked. If changing hardware configuration, for example, switching from using the internal JN5168 of an RD6040 gateway to a USB dongle or vice-versa, untick the check-box

9 Click “Choose file”.

10 Browse for the location of the Gateway firmware binary file, as supplied in the Application Note package or built from the supplied sources, select and then click “Open”.

11 Click “Flash Image” – this will display the “Flash Firmware – Verify” page which allows you to check the size and checksum of the image.



12 Click “Proceed” to start the memory update process. The following screen is displayed:

DO NOT TURN OFF POWER TO THE ROUTER UNTIL THE UPDATE IS COMPLETE.

Linksys router

During the reprogramming process the power LED begins to flash and then stays lit and is then followed by the bar LED below the Linksys logo starting to flash. When this LED stops flashing and remains illuminated the reprogramming and associated reboot has completed, meaning that the Router can be contacted again.

NOTE: reprogramming the Router will return all settings for the Router and Control Bridge back to their defaults, and it may be necessary to re-enable Wifi and change the operating channel of the Control Bridge.

JN-RD-6040 Gateway

Allow the RD6040 Gateway to boot up; the boot process is indicated by the yellow LED (boot status) flashing and then showing solid when up and running. The leftmost red LED will flash regularly showing the Linux kernel is up and running; when the Green LED (Ethernet activity) begins flashing, indicating the Gateway has booted up and is contacting other devices on the Ethernet interface. The Blue LED indicates when power is applied.

Revision History

Version	Notes
1.0	Initial release
1.1	Package updated with extra software components
2.0	Updated with new web-UIs
2.1	Host and Control Bridge software updated as described in JN-AN-1194b and JN-AN-1194c

Important Notice

NXP Semiconductors

For the contact details of your local NXP office or distributor, refer to:

www.nxp.com