Mesh Potato
Small Enterprise / Campus Network

User Guide

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1. Introduction

The Small Campus Network firmware is designed to allow a collection of Mesh Potato (MP) devices to provide a data and telephony network for a small campus.

The intended use is typically for a small/medium size organisation which needs to set up a number of workpoints spread over a limited geographic area, with each workpoint being equipped with a phone and a networked PC, and to do this wirelessly without using conventional LAN cabling.

The meshed MP devices utilise an OSI Layer 2 protocol and simply act as one large switch, transparently connecting all the attached devices together.

Each MP device provides a telephone connection, an ethernet cable connection and a WiFi Access Point. PCs and other network devices may be connected to the ethernet port of an MP, or connect wirelessly to the WiFi Access Point of each MP.

The wifi access point is encrypted with WPA by default in order to provide some protection from abuse of the data network as long as the pass phrase/key is kept confidential.

If one or more of the MP devices is connected via its ethernet port to a LAN with a router / DHCP server and internet access, any PC connected either by ethernet cable to an MP or by WiFi, will be able to acquire a DHCP address on the LAN and connect to the internet via the router.

Similarly, networked devices such as printers or storage devices may be attached to the LAN via an MP. All attached devices will appear on the LAN and will be visible to each other.

Each MP device provides a telephone port which may be called from another MP telephone by dialling the IP address of the required device. Abbreviated dialling is also supported so that a call may be made by dialling just the last octet of the required IP address.

To use telephony off the local mesh, individual MPs can be configured to access a VoIP Service Provider account for outgoing and incoming calls.

Configuration and management of individual MP devices is possible via telephone IVR, browser or terminal sessions with access to the underlying Linux operating system and OpenWRT software.

2. Overview of SECN Operation

This configuration uses Batman-advanced for the mesh rather than Batman as used in earlier firmware versions. Batman-advanced uses a different mesh protocol to batman and so the two won't interoperate on the same mesh.

The MP device provides two physical network interfaces, ethernet cable and wireless, which are configured as follows:

- The **eth0** interface operates on the MP ethernet cable connection.
- Two wireless interfaces, **ath0** and **ath1**, are set up on the wireless interface **wifi0**.
- Batman-adv is configured to run on the **ath0** interface using the *batctl* command and generates the **bat0** interface.
- The second wireless interface, **ath1**, is set up to operate as a WiFi access point using the *iwconfig* command.
- The **bat0**, **ath1** and **eth0** interfaces are bridged (**br-lan**) together in each MP and assigned a static IP address, and thus, due to the operation of the mesh via bat0, all the ath1 and eth0 interfaces of all the MPs in the mesh are similarly bridged.
- The default IP address range used for the **br-lan** interface is 10.130.1.x

The mesh will operate in a stand-alone configuration, simply connecting attached devices together and providing telephony between devices. Alternatively the mesh may be interconnected to a LAN to provide access to additional resources, including internet connectivity.

If one of the MP devices is connected via ethernet cable to a LAN router, then all wifi and ethernet interfaces connected to the meshed MPs will have access to the LAN resources.

If there is a DHCP server running on the LAN (eg in the router) then devices configured as DHCP clients connected to the MPs will acquire an IP address just as if they were connected directly to the LAN.

Note that there is no DHCP server running in a stand-alone mesh arrangement by default, and so in this case, attached devices would need to be statically configured for their IP address.

2.1 IP Address Range for MPs

It should be noted that the IP address used for the **br-lan** bridge in the MP devices needs to be configured during setup, and **may** or **may not** be made to lie in the IP address space used on the LAN to which the mesh may be connected. Operation is essentially the same in both cases, but care must be taken to manage the address space in the former case.

IP addresses assigned to MP devices are static. If the IP addresses used for the MP devices lie in the same address space as the LAN, then the DHCP server and other devices on the LAN must be appropriately configured so that the addresses assigned to the MP devices are left free in order to avoid IP address conflicts. In this arrangement, the MP devices will appear on the LAN just as any other device with a static IP address, and they may be accessed for management via browser or ssh terminal session.

Conversely, if the IP address range used for the MP devices is separate to that used on the LAN, the MP devices will not appear on the LAN and there is no need to reserve the address space. In order to access the MPs for management in this configuration, it is necessary to configure a PC with a static address in the same range as the MPs, and attach via Ethernet cable or WiFi.

The default IP address assigned to the **br-lan** interface in the MPs is 10.130.1.20 which is unlikely to conflict with the default address range of commodity routers.

If it is desired to have the MPs appear on the LAN, the **br-lan** IP address should be assigned accordingly during set up.

The address assigned to the **br-lan** interface for each MP must be changed to be unique, so that each device can provide a separate telephone number. This IP address assignment may be made by a number of methods including telephone IVR, web interface or manipulation of the */etc/config/network* file.

2.2 Batman-Advanced Operation

Batman-advanced is a "OSI layer 2" routing protocol which is implemented as a kernel module in the Linux kernel. Since Linux 2.6.38 batman-advanced is an official part of Linux.

When you assign at least one active physical network interface to batman-advanced, it will create the virtual ***bat0*** interface. In the SECN firmware ***ath0*** is assigned to the batman-advanced kernel module. ***ath0*** is the wireless interface operating in multipoint-to-multipoint mode (ad-hoc).

Because batman-advanced operates entirely on MAC layer (OSI layer 2), ***ath0*** doesn't need any Layer 3 configuration. Only its Layer 2 MAC address is required. The MAC address is configured during production, so we don't need to configure it. All we need to do is make sure to switch ***ath0*** on. To sum it up: ***ath0*** is the link-local transport interface for the batman-advanced mesh.

Batman-adv itself bridges all ***bat0*** interfaces in all the mesh devices to a big, smart, virtual switch. This means that all ***bat0*** interfaces in the mesh are link-local - even if they are multiple wireless hops away.

Despite being virtual, ***bat0*** acts like a real, physical, network interface connected to a big switch. As such you can run all kinds of network protocols on it, like IPv4, IPv6, ARP, Zeroconf (yes, you can run mDNS on ***bat0***!), IPX – or whatever protocol that can communicate over a network interface that is connected link local (which means directly connected, like a straight Ethernet cable connected between two computers, or a bunch of computers connected to a switch).

In the SECN firmware the ***bat0*** interface itself is again assigned (or rather enslaved) to a bridge in each machine. ***bat0*** is part of the bridge named ***br-lan***, together with ***ath1*** and ***eth0***.

eth0 is the LAN port of the MP. ***ath1*** is a access-point interface, operating as a master in WiFi infrastructure mode. (As opposed to a infrastructure client, like laptops or smartphones with a WiFi interface).

Hence **all** eth0 and ***ath1*** interfaces in **all** devices running the SECN firmware are part of **one** big wireless bridge. The ***ath0*** interface does the low level work to carry the traffic link-locally from hop to hop and batman-advanced takes care about the routes that the MAC packets have to take.

Note: It is not possible to add IP settings to an interface which is encapsulated in a bridge - you can only assign IP settings to the bridge interface itself. ***eth0*** is part of the bridge ***br-lan,*** together with ***ath1***, ***bat0*** (the batman-advanced virtual interface, which is routed by the mesh routing protocol on MAC level). Hence you can not assign any IP settings to ***eth0***, ***ath1*** or ***bat0*** - only to ***br-lan***.

2.3 Telephony Operation

Overview

MP devices provide an RJ11 port to which a telephone may be connected and each MP device runs a copy of the Asterisk application to provide the telephony facilities. Asterisk allows phone calls to be made between devices by means of Voice over IP (VoIP) and Session Initiated Protocol (SIP).

The operation of Asterisk is controlled to a number of configuration files, two of which are of particular interest for MP devices - ***/etc/asterisk/extensions.conf*** and ***/etc/asterisk/sip.conf***
The ***extensions.conf*** file sets up the dial plan while the ***sip.conf*** file defines the channels to be used for making calls.

Operation of Asterisk can be monitored from the MP command line by executing the command:

```
# asterisk -r
```

Useful commands in the Asterisk shell include:

CLI> exit	Return to the command shell
CLI> core set verbose 5	Set verbose level to 5
CLI> sip reload	Reload sip.conf configuration
CLI> dialplan reload	Reload extensions.conf dialplan
CLI> show dialplan default	Display current dial plan
CLI> sip show registry	Display sip registrations

The MP Asterisk configuration includes several telephone extension numbers that allow interaction with the device using Interactive Voice Response (IVR) system. These numbers include:

2663 (C-O-N-F)	Configure the IP address of the device
2661	Read out the ath0 wireless interface IP
2664	Read out the eth1 Ethernet interface IP
7774	Read out the rssi signal strength
3427	Start DHCP client on eth0

The SECN firmware includes a facility for making calls using abbreviated dialling using the last octet of the device IP address by pre-pending the rest of the address. This is set up on re-boot by the script ***/bin/generate-extension.sh*** using the MP device's own br-lan IP address as reference**.**

Making Calls to MP Devices

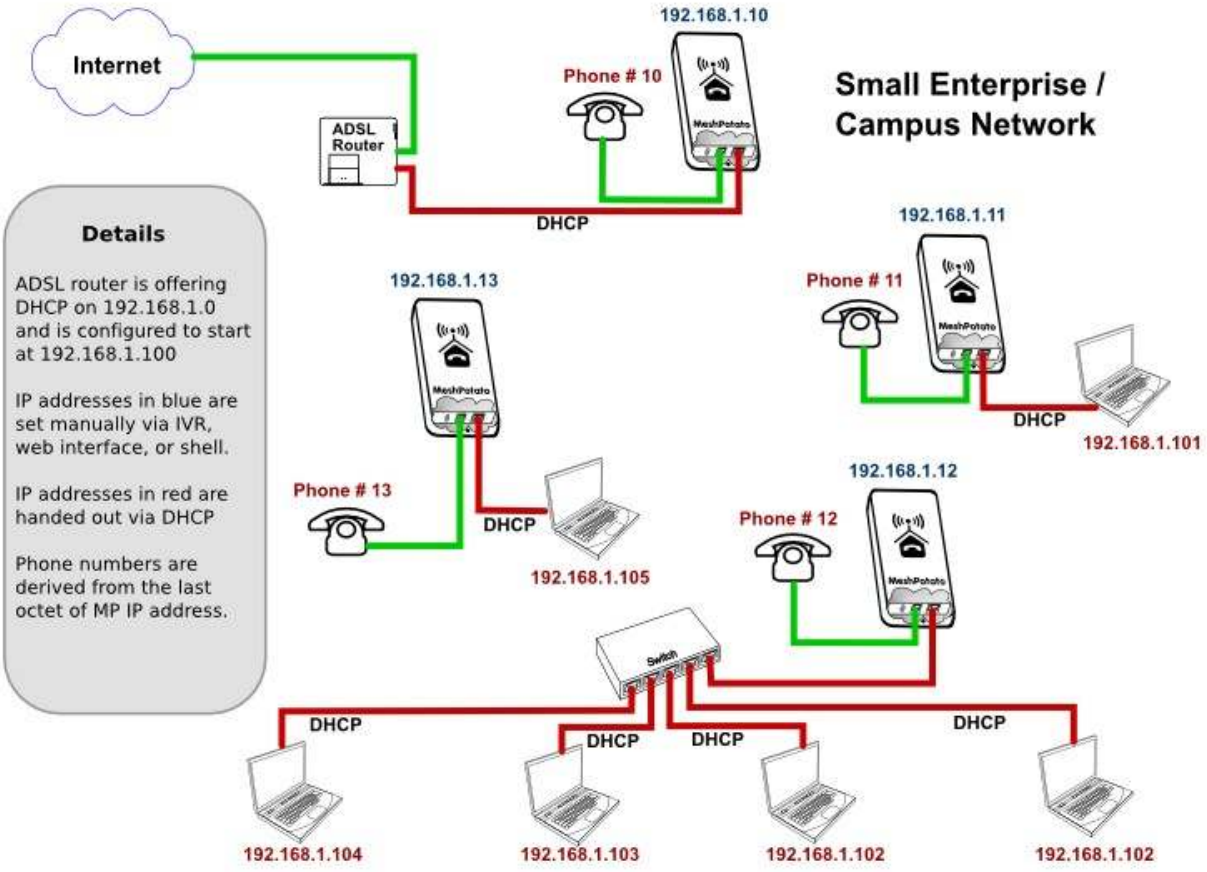
To dial an MP device using the full IP address, dial the IP number substituting the * character for the dots between octets in the address. To dial an MP with address 10.130.1.21, dial

```
10*130*1*21
```

To dial an MP device using abbreviated dialling, simply dial the last octet of the unique IP number assigned to the required MP. This can be dialled as 1, 2 or 3 digits eg

005, 05, 5	(device address 10.130.1.5)
025, 25	(device address 10.130.1.25)
105	(device address 10.130.1.105)

2.4 Example Network



3. Setting Up MP Devices

3.1 Flash the Firmware

If you have purchased a new MP device, it will normally be delivered from the factory with firmware version rv233 installed. To operate the SECN configuration, you will need to flash the MP with rv278 firmware .

Download firmware from:

http://elektrad.info/download/MESH-POTATO/

Download the ***.img .squashfs .lzma*** files for the rv278 firmware version and save to a working directory.

Refer to the general instructions in ***Upgrading Mesh Potato Firmware HowTo*** on the Village Telco Wiki. Following is a brief description of the flashing process.

- Connect the MP directly to your PC with an Ethernet cable with the MP power **off**
- Execute potato-flash:
  $ sudo potato-flash eth0 openwrt-atheros-root-rv278.squashfs openwrt-atheros-vmlinux-rv27.lzma
- Wait for the program to start looking for the MP device - a series of dots will appear on the screen.
- Switch the power **on** to the MP.
- Wait for the flashing process to complete and for the MP to restart.
  This will take several minutes.
- Wait for three minutes after the MP WifF led starts to flash to ensure that flash is complete.

Sample MP Flash Session

$ sudo potato-flash eth0 openwrt-atheros-root-rv238.squashfs openwrt-atheros-vmlinux-rv238.lzma

Reading rootfs file openwrt-atheros-root-rv238.squashfs with 3801088 bytes ...
Reading kernel file openwrt-atheros-vmlinux-rv238.lzma with 720896 bytes ...
Note: The device has to be connected directly (not via switch/hub)
Device detection in progress.....

<<< Turn the power to the MP device ON at this point >>>

….....device detection: non-arp packet received..
Peer MAC: 00:09:45:58:1c:e7
Peer IP : 192.168.1.184
Your MAC: 00:ba:be:ca:ff:ee
Your IP : 192.168.1.0
Connecting to Redboot bootloader
WARNING: UNPLUGGING POWER WHILE FLASHING MIGHT DAMAGE THE BOOTLOADER
HOWEVER: IF YOU SEE NOTHING SHOWING UP BENEATH THIS LINE
FOR MORE THAN A MINUTE, START AGAIN...
A flash size of 8 MB was detected.
rootfs(0x006a0000) + kernel(0x00100000) + nvram(0x00000000) sums up to 0x007a0000 bytes
Setting IP address...
Initializing partitions...
Now uploading kernel...
Sending kernel, 1408 blocks...
Flashing kernel...
Loading rootfs...
Sending rootfs, 7424 blocks...
Flashing rootfs...
Flashing process completed...
Restarting device...

3.2 Minimum Set-up

The minimum set-up process uses the telephone IVR facility to simply set a unique IP address for the ***br-lan*** bridge interface in order to allow telephone calls to the device using the IP address.

The default setting for this IP address when the device is flashed is 10.130.1.20 and you should change at least the last octet of the address in order to make the address unique on the mesh.

In a simple mesh arrangement, all MP devices on the mesh are assigned addresses in the same address range (ie only the last octet of the address is changed) so telephone calls can be made to all devices on the mesh with abbreviated dialling using just the last octet of the MP device's bridge IP address.

If you are intending to connect the mesh to a LAN, you may choose to assign addresses from the LAN address space to the MP devices so that they will appear as static IP devices on the LAN. In this case, just set the Ipv4 address field to the required IP address. You will need to ensure that the address that has been assigned will not be used by any other device on the LAN in order to avoid IP conflicts.

Set the *br-lan* IP Address

Connect a telephone to the MP device and wait until the device has fully restarted.

Pick up the telephone, check for dial tone and dial 2663 (C-O-N-F)
Follow the voice prompts and enter the IP number in the form
10*130*1*21 (For an IP address of 10.130.1.21)
The number entered will be read back to you and the MP will reboot.

After the device has rebooted, you should be able to make a call to the device using either the full IP number, or abbreviated dialling using just the last octet of the address.

3.3 Basic Set-up

The basic set-up uses the OpenWRT web interface of the MP device and allows you to set the password for the ***root*** account, set ***br-lan*** bridge IP address, and set the ***ath0*** mesh interface address.

Connect your PC to the MP device with an Ethernet cable.

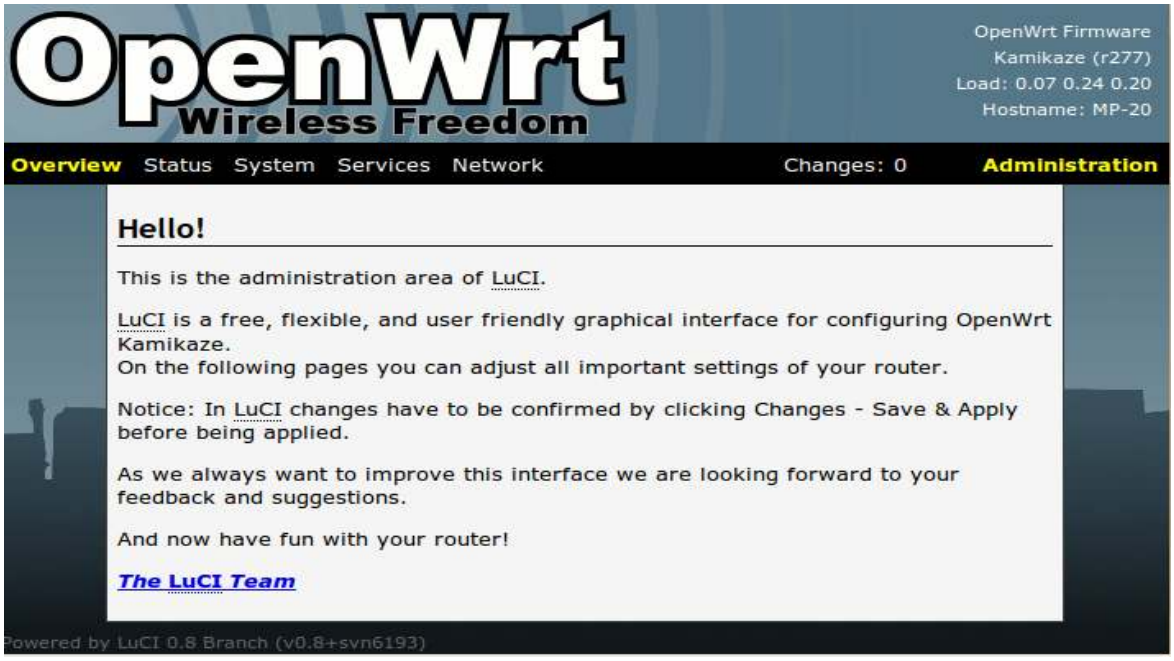
Set up a network profile for the Ethernet port on your PC with:

Static IP: 172.31.255.253 and

Netmask: 255.255.255.252

Point your browser to the MP Fallback address http://172.31.255.254
This will bring up the OpenWRT LUCI login screen.

After flashing the MP device there will be no password set for the ***root*** account, so you can log in with the password field blank.

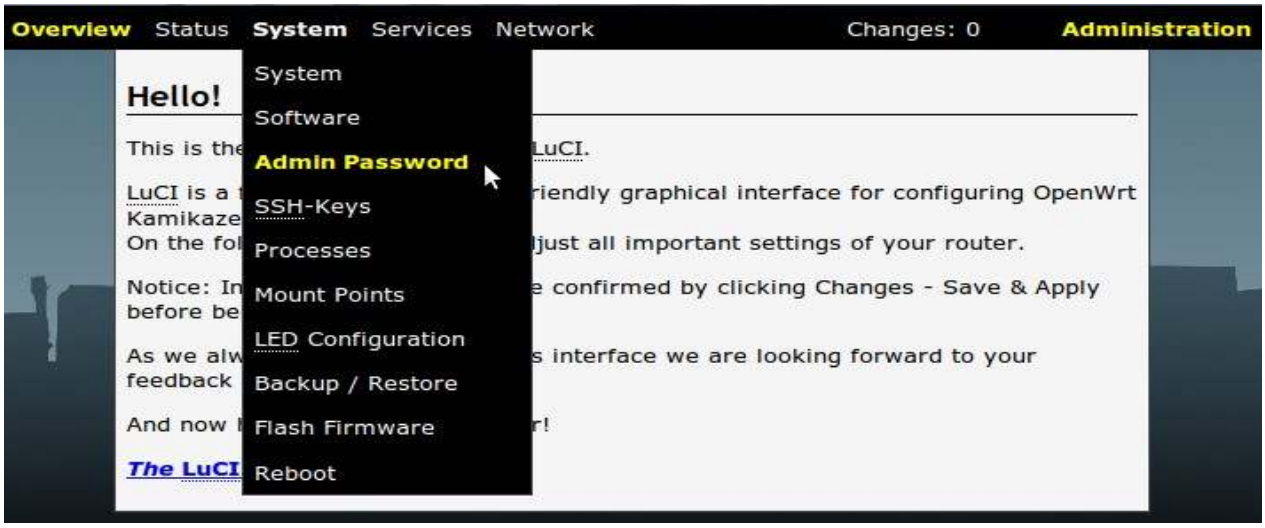


Set the Root Password

Select ***System / Admin Password*** from the menu and enter the new password.

Then click on the ***Save & Apply*** button at the lower right of the page.

Once the password as been set and the change committed, future logins will require the password to be entered. In addition, ***telnet*** connections will be disabled and ***ssh*** sessions will be required for terminal session connections.



Set the br-lan Bridge IP Address

This step sets the unique IP address for the ***br-lan*** bridge interface which is used for making telephone calls to the MP device, and may be used to access the MP device for maintenance.

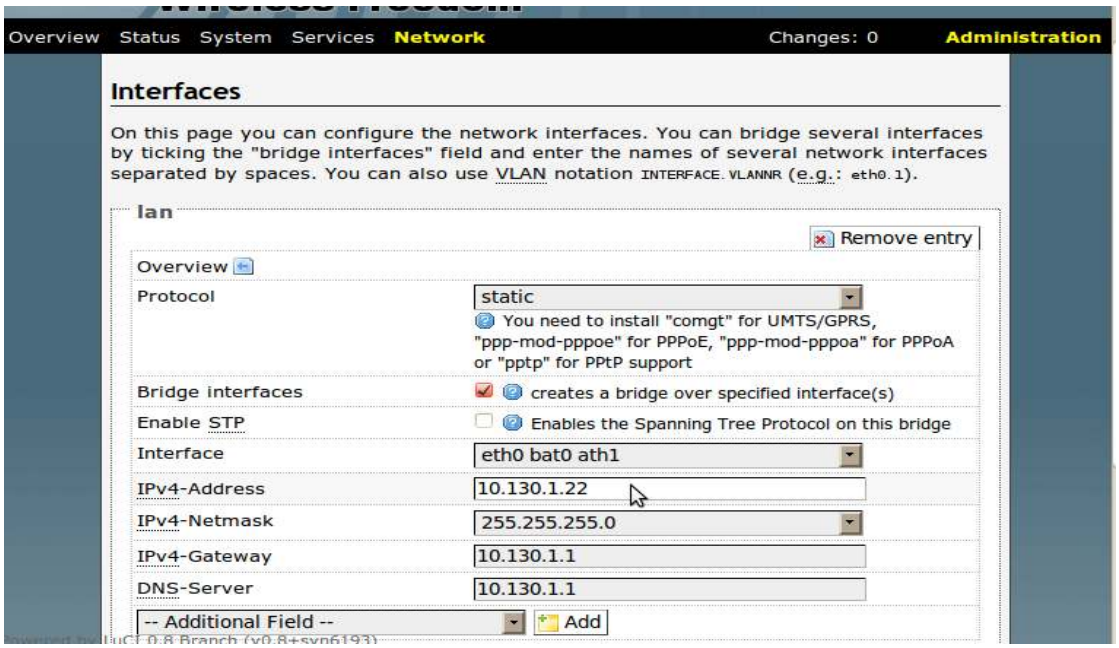
The default setting for this IP address when the device is flashed is 10.130.1.20 and you should change at least the last octet of the address in order to make the address unique on the mesh.

In a simple mesh arrangement, all MP devices on the mesh are assigned addresses in the same address range (ie only the last octet of the address is changed) so telephone calls can be made to all devices on the mesh with abbreviated dialling using just the last octet of the MP device's bridge IP address.

If you are intending to connect the mesh to a LAN, you may choose to assign addresses from the LAN address space to the MP devices so that they will appear as static IP devices on the LAN.
In this case, just set the Ipv4 address field to the required IP address. You will need to ensure that the address that has been assigned will not be used by any other device on the LAN in order to avoid IP conflicts.

From the LUCI web interface menu select ***Network / Interfaces / LAN***
Interface : eth0 bat0 ath1
Set the required IP address for the device eg :
IPv4-Address: 10.130.1.22

Click on the ***Save*** button at the bottom right of the screen.
This will just save the change but not apply it until the ***Save&Apply*** button is selected. This allows you to make other network configuration changes before the changes are committed and the device restarts.



Set the ath0 IP Address

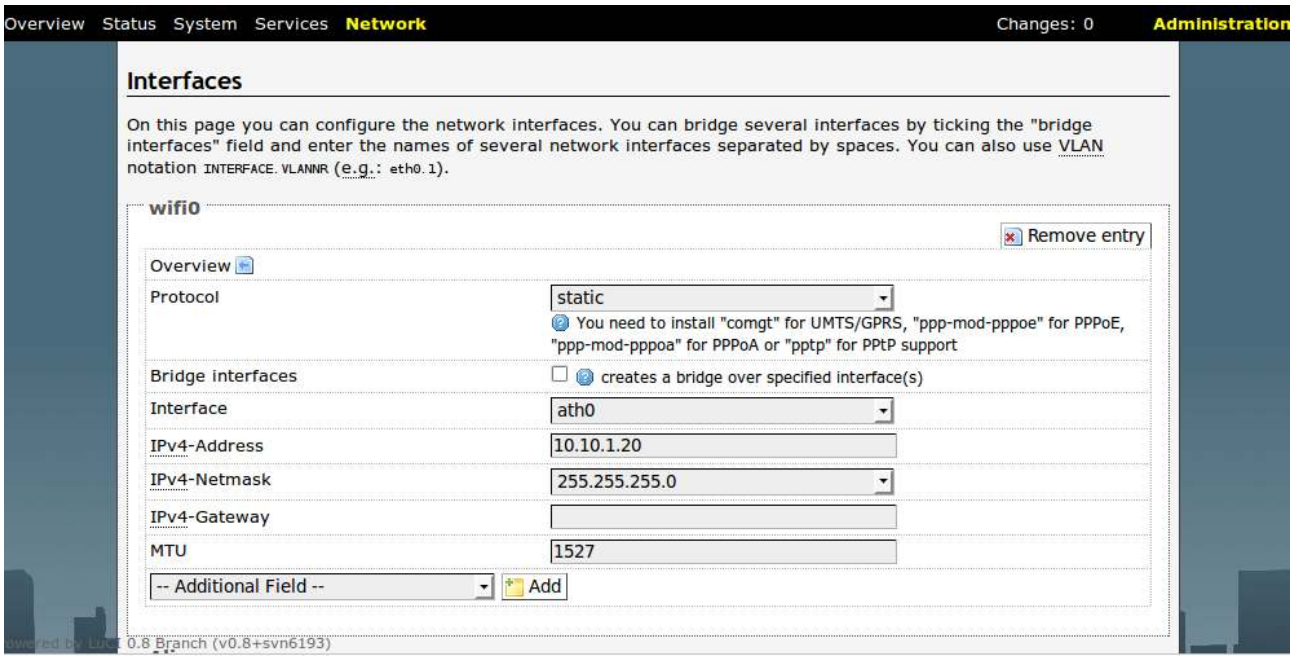
This step sets a unique IP address for the ***ath0*** mesh interface. Changing this address is optional – the device will perform in the mesh just as well without any change.

One reason you might want to change this address is to allow connection to the device for maintenance purposes at a unique address with a PC able to operate in ***ah-demo*** WiFi mode. Conversely, leaving all the ***ath0*** addresses the same provides a known fallback address that will work on any device.

The default setting for this IP address when the device is flashed is 10.10.1.20 and you may choose to change just the last octet of the address in order to make the address unique on the mesh, or you may choose to change the whole address range.

If you are changing the last octet of the address, it is a useful convention to make it the same as the bridge address.

When you have made any required change, click ***Save*** at the lower right of the page.
When all required network changes have been made, click ***Save&Apply*** to commit the changes and restart the device.



3.4 Advanced Set-up

Use the command line from a ***telnet*** or ***ssh*** terminal session.

Connecting to the MP

Connect to the MP via ***telnet*** using the MP fallback address: 172.31.255.254
Set PC to: IP: 172.31.255.253 Netmask: 255.255.255.252
Set the ***root*** password and exit.

Connect to the MP via ***ssh*** and login.

Set the MP Network Addresses

Set the br-lan Bridge IP Address

Set the unique IP address for the ***br-lan*** interface of the MP device by using the uci command or by directly editing the network configuration file.

From the command line:

```
uci set network.br-lan.ipaddr=103.130.1.XXX    (Where xxx is unique to each MP)
uci commit network
```

Edit the ***/etc/config/network*** file:

```
config 'interface' 'lan'
        option 'type' 'bridge'
        option 'ifname' 'eth0 bat0 ath1'
        option 'proto' 'static'
        option 'netmask' '255.255.255.0'
        option 'gateway' '10.130.1.1'
        option 'dns' '10.130.1.1'
        option 'ipaddr' '10.130.1.22'
```

Set the ath0 IP Address

You may wish to change the ath0 IP address, however this is not required for basic mesh operation.

From the command line:

```
uci set network.wifi0.ipaddr=10.130.1.XXX       (Where xxx is unique to each MP)
uci commit network
```

Edit the ***/etc/config/network*** file:

```
config 'interface' 'wifi0'
        option 'ifname' 'ath0'
        option 'proto' 'static'
        option 'ipaddr' '10.10.1.20'
        option 'netmask' '255.255.255.0'
        option 'mtu' '1527'
```

Set the AP BSSID and Password

Edit the ***/etc/hostapd.conf*** file

```
interface=ath1
bridge=br-lan
driver=madwifi

# Edit BSSID as required
ssid=Mesh-Potato-AP

country_code=DE
hw_mode=g
wpa=1
wpa_passphrase=potato-potato
wpa_key_mgmt=WPA-PSK
macaddr_acl=0
ctrl_interface=/var/run/hostapd
```

Modifying Asterisk Operation

Setting up External VoIP

To add external VoIP support, changes are required to two Asterisk configuration files (***sip.conf*** and ***extensions.conf***) on the individual MP where the access is required.

1. In the ***/etc/asterisk/sip.conf*** file make the following changes:

a) In the ***[general***] section, add the following lines to register with the VoIP provider:

```
; Register to VoIP Provider
register => myusername:mysecret@mysipprovider.com
```

b) Add a new ***[sipaccount]*** section to define the account details:

```
[sipaccount]
host=sip.mysipprovider.com
secret=mysecret
username=myusername
fromuser=myusername
insecure=port,invite
type=friend
disallow=all
allow=gsm,ulaw,alaw
dtmfmod=rfc2833
qualify=yes
canreinvite=no
nat=yes
context=default
```

2. In the ***/etc/asterisk/extensions.conf*** file add the following lines at the start of the ***[default]*** section:

```
; Send incoming calls to the MP
exten => s,1,Dial(MP/1)
; Make outgoing calls using [sipaccount] details
; Dial # for access, and then required number string
exten => _#.,1,Dial(SIP/${EXTEN:1}@sipaccount,120,r)
```