pureLiFi Management VM Manual

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1. Introduction

This document describes the installation and usage of pureLiFi Management Virtual Machine. The machine provides both TR-069 and SNMPv3 configuration frontends for configuration and monitoring of LiFi Access Points. Exported Virtual Machine format (.ova) makes it easy to deploy in user's network environment. The VM is compatible with most common Virtual Machine Managers (however, the provided image might require conversion for some VMMs).

Key components of the system are:

- FreeACS – for TR-069 management
- SNMPv3 Command Line Interface tools (snmpget, snmpset, etc.)
- Proprietary light management software (UDP-based) with WEB GUI and PHP frontends
- DHCP server – for initial AP configuration and/or for system IP assignment

1.1. Purpose

TR-069 (Technical Report 069) is a technical specification that defines an application layer protocol for remote management of end-user devices. It was published by the Broadband Forum and titled CPE WAN Management Protocol (CWMP).

As a bidirectional SOAP/HTTP-based protocol, it provides the communication between customer-premises equipment (CPE) and Auto Configuration Servers (ACS). It includes both a safe auto configuration and the control of other CPE management functions within an integrated framework. The protocol addresses the growing number of different Internet access devices such as modems, routers, gateways, as well as end-user devices which connect to the Internet, such as set-top boxes, and VoIP-phones. The TR-069 standard was developed for automatic configuration and management of these devices by Auto Configuration Servers (ACS).

Simple Network Management Protocol (SNMP) is an Internet Standard protocol for collecting and organizing information about managed devices on IP networks and for modifying that information to change device behaviour. Devices that typically support SNMP include cable modems, routers, switches, servers, workstations, printers, and more.

SNMP is widely used in network management for network monitoring. SNMP exposes management data in the form of variables on the managed systems organized in a management information base (MIB) which describe the system status and configuration. These variables can then be remotely queried (and, in some circumstances, manipulated) by managing applications.

Three significant versions of SNMP have been developed and deployed. SNMPv1 is the original version of the protocol. More recent versions, SNMPv2c and SNMPv3, feature improvements in performance, flexibility and security.

SNMP is a component of the Internet Protocol Suite as defined by the Internet Engineering Task Force (IETF). It consists of a set of standards for network management, including an application layer protocol, a database schema, and a set of data objects.

1.2. System description

The pureLiFi Management Virtual Machine runs on Linux Mint 17.3 "Rosa". It serves mainly as a configuration server for LiFi-X and LiFi-XC APs.

FreeACS software is used as an implementation of the TR-069 protocol. It is responsible for storing and applying configuration settings to each of the APs. The provisioning is initiated once the AP is powered on, and all the configurations from the server are downloaded to the AP. Next connections occur in specified intervals that could be set inside ACS software. Apart from that the periodic provisioning the server also allows disruptive provisioning, *i.e.,* requesting the AP to connect to the server outside of the specified intervals. Last feature of the ACS is that it supports software updates. The software update can be applied either to single AP, group of APs or all available APs. When software update mode is selected the AP will be updated upon next provisioning (either periodic or forced).

SNMP CLI tools are used to configure the unit using SNMPv3 protocol (using MD5 authentication and DES encryption). In addition to SNMPv3 the system also supports community based SNMPv1 and SNMPv2c. However, those can only be used to monitor the system performance, as neither of them have WRITE permissions. In the deployments where security is the main concern, both SNMPv1 and SNMPv2c protocols can be disabled, leaving only SNMPv3 protocol operational.

Apart from the ACS and SNMP software, the virtual machine also provides utilities to set brightness and power modes of different APs. This is achieved using pureLiFi proprietary protocol. This tool can work both in multicast and unicast modes – applying changes to either one or a group of APs.

The VM also a DHCP server installed, that is disabled by default. However, if desired the operator can use it as a main DHCP server for LiFi network.

The DHCP server is also used to set-up TR-069 provisioning. It provides the IP of the ACS Server to the APs, so that the access points know where to start provisioning.

2. pureLiFi Management

2.1. Installing pureLiFi Management virtual machine.

In order to install pureLiFi Management virtual machine, import attached OVA image to preferred Virtual Machine manager (currently supporting VMware and Virtual Box, but the image can be easily converted to support other Virtual Machine Managers). The login credentials to the OS are: Username – purelifi, Password – purelifi.

2.1.1. Setting up network

In a final deployment, ACS should have a static IP address in order to make sure automatic provisioning works correctly. APs detect the address of the available ACS machine on start-up and then communicate with this address until next reboot. Therefore, it is important to assign the static IP address of the server, before deploying the whole LiFi-X system.

To change the IP address, one can use the build-in network manager (it can be found in Start Menu -> Control Centre -> Network Connections).

2.1.2. Setting up tomcat7 (FreeACS web server) (optional step)

pureLiFi-ACS comes with mostly pre-configured FreeACS package. However, in order to enable forced provisioning, IP address needs to be specified in

/var/lib/tomcat7/common/xaps-stun.properties

By default, it is set to 127.0.0.1, which would work for non TR-111 devices. However, one may desire to specify it, so that it matches static IP of the ACS. In order to change it, in the file above find a line:

```
# Primary ip. Specify the default public interface of your server
primary.ip = 127.0.0.1
```

and change the IP address to the address that was set up in the previous step. That will ensure the STUN server is running and bound to the correct IP.

Warning:

If the IP of the ACS is changed, the STUN server properties should also be updated to ensure the correct operation of the server.

2.1.3. Provisioning ACS IP address to LiFi Access Points

In order for the APs to start TR-069 provisioning, they need to know the static IP address of the Management VM (as set in step 2.1.1). The system uses DHCP frame tag no. 235 to provision the ACS IP address to the APs. The pre-configured DHCP server, that is part of the Management VM has this option already defined and set to an example value (please see section 2.6. for more details).

The operator may wish to configure an existing DHCP server, to provision the ACS IP address as tag no. 235 of the DHCP frame. If this is not possible, it is recommended to use the build-in DHCP server (at least for the initial setup – once the ACS IP has been received by the AP it will be stored in the internal memory).

2.2. FreeACS and TR-069 provisioning

Detailed operation of the FreeACS server web interface is described in Fusion Web User Manual provided along this manual. A copy of the manual is also included inside the Virtual Machine under *~/Documents* directory. Please read through it prior to continuing with this manual, as it describes basic usage of FreeACS software.

To access the server from within the Virtual Machine open browser and type in the following address: *localhost:8080*, to access the server from other computers inside the network replace **localhost** with the IP address of the server. The address should look something like: *10.10.1.15:8080*. Once accessed, the server will ask for user credentials. The defaults are: User – "admin"; Password – "xaps".

Warning:

It is highly advisable to change the password for admin user and add other non-admin users as required.

Table 1 presents all parameters being provisioned between pureLiFi-ACS and LiFi-X AP. The parameters included in categories "InternetGatewayDevice.LANDevice." and "InternetGatewayDevice.LiFi.1." categories will require changing, since those two categories hold all the LiFi network parameters (IP address, network mask, IP protocol type, authentication type etc.) and lamp properties (maximum current allowable through the lamp, initial brightness, etc.).

Warning:

Please be cautious when changing parameters included inside "InternetGatewayDevice.ManagementServer." category. Using improper values in that category might break the communications between the AP and ACS. Changing *Username* of the AP will effectively change the Unit Id and hence a new profile would be created with the newly specified *Username*. Once new unit is created it is safest to delete the old Unit Id, to avoid any undesired behaviour in the future. Once Unit Id is changed, the AP will hold that new name for all future provisioning. In order to restore the factory default, first set the *Username* of the AP to "easycwmp" and reboot it. After reboot new Unit Id will appear, which would be a factory given one.

Parameter	Attribute	Description
InternetGatewayDevice.DeviceInfo.		
DeviceLog	R	
HardwareVersion	R	
Manufacturer	R	
ManufacturerOUI	R	
ProductClass	R	
ProvisioningCode	RW	Automatically assigned by ACS
SerialNumber	R	
SoftwareVersion	R	
SpecVersion	R	
UpTime	R	
InternetGatewayDevice.LANDevice.1.WLANConfiguration.1.		
Enable	RW	Enable/Disable LAN
SSID	RW	LiFi Network SSID
MACAddress	R	MAC of LiFi interface
Protocol	RW	Interface protocol (static/dhcp)
IPAddress	R	Current IP Address of the AP
IPAddress_set	RW	IP address for static interface protocol
NetMask	RW	Network mask for static interface protocol
Gateway	RW	Gateway for static interface protocol
AuthenticationMechanism	RW	none/psk2/wpa2
WPAPassword	RW	For WPA Enterprise it is a password to access RADIUS server, for PSK – a network password
RADIUSServerIPAddress	RW	IP address of the RADIUS server

802_1xDynamicVLANs	RW	Enable/disable 802.1x dynamic VLAN support
ConnectedSTAs	R	MAC Addresses of all connected STAs
AvailableVLANs	RW	List all availble VLANs on a Trunk, excluding the Native VLAN (comma separated values)
WirelessStaticVLAN	RW	Statically bind wireless interface to a specific VLAN (VLAN must be listed in *AvaliableVLANs* parameter)

InternetGatewayDevice.LiFi.1.		
LampConfiguration.1.		
Enable	RW	Startup lamp status: 0 – off 1 - Light on, LiFi off 2 – both on
MaxLampCurrent	RW	Maximum DC current that can be allowed through the lamp [mA]
LampOffsetCurrent	RW	Initial lamp offset current [mA]
LampModulationDepth	RW	Initial modulation depth [%]
MulticastGroup	RW	Multicast group address
DriverVoltage	RW	Target driver voltage (between 1V and 6V)
PoeConfiguration.1.		
LampPower	RW	Max Lamp Power (for PoE negotiation)
802_3at	RW	0: PSE supports 802.3af only (P_{max}=12.9W) 1: PSE supports 802.3at/UPoE
InternetGatewayDevice.ManagementServer.		
URL	RW	ACS TR-069 URL
Username	RW	AP Username (also Unit ID)
Password	RW	AP connection password

PeriodicInformEnable	RW	Auto-generated by FreeACS
PeriodicInformInterval	RW	
PeriodicInformTime	RW	
ConnectionRequestURL	R	AP address to force provisioning
ConnectionRequestUsername	RW	AP username for forced provisioning
ConnectionRequestPassword	RW	AP password for forced provisioning
ParameterKey	R	Auto-generated
InternetGatewayDevice.WANDevice.1.WANConnectionDevice.1.		
WANIPConnection.1.		
ConnectionStatus	R	
MACAddress	R	MAC address of Ethernet interface

Table 1. pureLiFi LiFi-X TR-069 provisioned parameters.

2.3. Software upgrade over TR-069

Additional feature of FreeACS is that it can provide easy way of upgrading software on multiple APs. In order to use software update feature, the software image needs to be added first.

Software update images come in .bin format, and are called as follows: *packed-x.x.x-LX-ap-fw.bin*, where *x.x.x* is a version number (e.g. *1.1* or *1.2.2*). To add the software package to the ACS one needs to go to Files&Scripts → Files, making sure that the correct Unit Type is selected (LiFi-X AP in Context navigation window is selected) (see Figure 1).
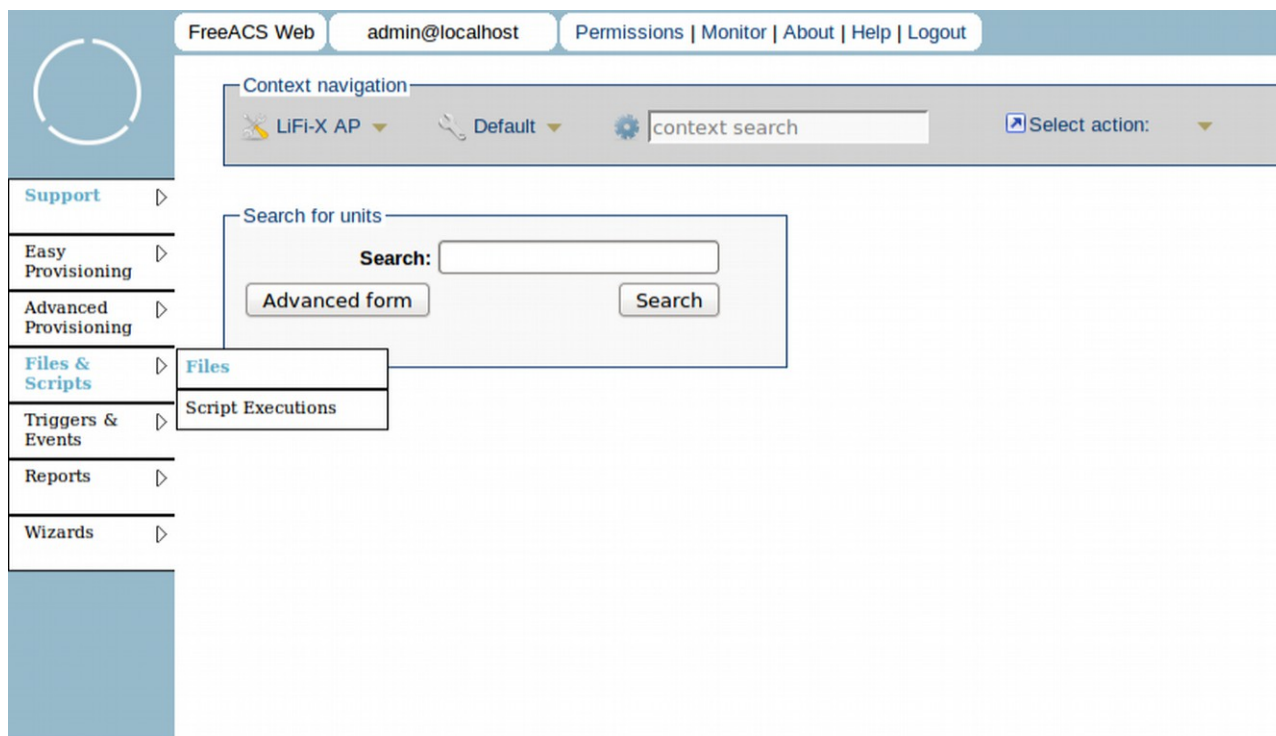
Figure 1. Adding software update package to ACS.

In the new window, choose the software package to be uploaded. Specify the "Version:" field in the uploader. It **must contain the same** version tag as the update package (e.g. **1.2.2** for packed-**1.2.2**-LX-ap-fw.bin). Otherwise the update script will not work correctly. Once added, the new firmware version should show up in the drop-down menu in Unit configuration window (just as in Figure 2). To update the unit to newest firmware, one needs to simply select that firmware version from the drop-down menu in Unit configuration window and press upgrade. For instructions on upgrading multiple units at a time please refer to Fusion Web User Manual.
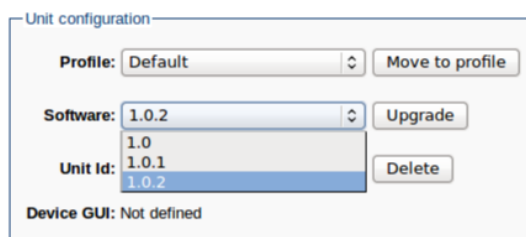

Figure 2. Updating AP using ACS Unit configuration window.

2.4. SNMP protocol

LiFi systems support a range of SNMP versions. These include:

- SNMP v1 Read/Only community: "SNMP-lifi_stats"
- SNMP v2c Read/Only community: "SNMP-lifi_stats"
- SNMP v3 Read/Write MD5 based authentication   "SNMP-lifi_admin"

The SNMP v3 user uses DES encryption. The user password is by default set to "LiFi-XC SNMP". The decryption password is the same. The password can be changed by a user, by changing snmpLiFiAdminUserPassword parameter (this will automatically update encryption password as well, so the two will always be the same).

LiFi specific MiB tree looks as follows:

```
+--snmpLiFiConfig(49120)
   |
   +--snmpLiFiLampConfig(1)
   |  |
   |  +-- -RW- EnumVal    snmpLiFiLampEnable(1)
   |  |        Textual Convention: PowerMode
   |  |        Values: off(0), analog(1), digital(2)
   |  +-- -RW- Integer32 snmpLiFiLampMaxCurrent(2)
   |  +-- -RW- Integer32 snmpLiFiLampOffsetCurrent(3)
   |  +-- -RW- Integer32 snmpLiFiLampModulationDepth(4)
   |  +-- -RW- String    snmpLiFiLampMulticastGroup(5)
   |  |        Textual Convention: InetAddressIPv4
   |  |        Size: 4
   |  +-- -RW- EnumVal    snmpLiFiLampDALIEnable(6)
   |  |        Textual Convention: TruthValue
   |  |        Values: false(0), true(1)
   |  +-- -RW- EnumVal    snmpLiFiLamp0-10VInterfaceEnable(7)
   |  |        Textual Convention: TruthValue
   |  |        Values: false(0), true(1)
   |  +-- -RW- INTEGER   snmpLiFiLampDriverVoltage(8)
   |           Textual Convention: Vdrain
   |
   +--snmpLiFiPoEConfig(2)
   |  |
   |  +-- -RW- EnumVal    snmpLiFiPoE8023at(1)
   |  |        Textual Convention: TruthValue
   |  |        Values: false(0), true(1)
   |  +-- -RW- Integer32 snmpLiFiPoELampPower(2)
   |
   +--snmpLiFiLightlinkConfig(3)
   |  |
   |  +-- -RW- String    snmpLiFiLightlinkSSID(1)
   |  |        Textual Convention: String
   |  |        Size: 0..255
   |  +-- -R-- String    snmpLiFiLightlinkMACAddress(2)
   |  |        Textual Convention: HWAddr
   |  |        Size: 6
   |  +-- -R-- String    snmpLiFiLightlinkConnectedSTAs(3)
   |  |        Textual Convention: String
   |  |        Size: 0..255
   |  +-- -RW- EnumVal    snmpLiFiLightlinkAuthenticationMechanism(4)
   |  |        Textual Convention: AuthType
```

```
|  |          Values: none(0), psk2(1), wpa2(2)
|  +-- -RW- String    snmpLiFiLightlinkWPAPassword(5)
|  |          Textual Convention: String
|  |          Size: 0..255
|  +-- -RW- String    snmpLiFiLightlinkRADIUSServerIPAddress(6)
|  |          Textual Convention: InetAddressIPv4
|  |          Size: 4
|  +-- -RW- EnumVal    snmpLiFiLightlink8021xDynamicVLANs(7)
|  |          Textual Convention: TruthValue
|  |          Values: false(0), true(1)
|  +-- -RW- String    snmpLiFiLightlinkAvailableVLANs(8)
|  |          Textual Convention: String
|  |          Size: 0..255
|  +-- -RW- EnumVal    snmpLiFiLightlinkWirelessStaticVLAN(9)
|          Textual Convention: WirelessVLAN
|          Values: disabled(0)
|
+--snmpLiFiProtocolManagement(4)
  |
  +-- -RW- EnumVal    snmpLiFiEnableROStatistics(1)
  |          Textual Convention: TruthValue
  |          Values: false(0), true(1)
  +-- -RW- String    snmpLiFiAdminUserPassword(2)
             Textual Convention: String
             Size: 0..255
```

The description of each of the above parameters can be found in Table 2.

Parameter Name	Access	Type	Values
snmpLiFiLampEnable	R/W	(i)nteger	off; analog; digital;
snmpLiFiLampMaxCurrent	R/W	(i)nteger	number in mA
snmpLiFiLampOffsetCurrent	R/W	(i)nteger	number in mA
snmpLiFiLampModulationDepth	R/W	(i)nteger	number in %
snmpLiFiLampMulticastGroup	R/W	(s)tring	ipv4 address
snmpLiFiLampDALIEnable	R/W	(i)nteger	false; true
snmpLiFiLamp0-10VInterfaceEnable	R/W	(i)nteger	false; true
snmpLiFiLampDriverVoltage	R/W	(i)nteger	3000 – 6000 (mV)
snmpLiFiPoE8023at	R/W	(i)nteger	false; true
snmpLiFiPoELampPower	R/W	(i)nteger	number in mW
snmpLiFiLightlinkSSID	R/W	(s)tring	SSID
snmpLiFiLightlinkMACAddress	R/O	(s)tring	MAC address
snmpLiFiLightlinkConnectedSTAs	R/O	(s)tring	station list
snmpLiFiLightlinkAuthenticationMechanism	R/W	(i)nteger	none, psk2, wpa2

snmpLiFiLightlinkWPAPassword	R/O	(s)tring	psk/radius password
snmpLiFiLightlinkRADIUSServerIPAddress	R/W	(s)tring	ipv4 address
snmpLiFiLightlink8021xDynamicVLANs	R/W	(i)nteger	false; true
snmpLiFiLightlinkAvailableVLANs	R/W	(s)tring	comma separated list of vlans or "none"
snmpLiFiLightlinkWirelessStaticVLAN	R/W	(i)nteger	"disabled" or VLAN number
snmpLiFiEnableROStatistics	R/W	(i)nteger	false; true
snmpLiFiAdminUserPassword	R/W	(s)tring	SNMPv3 access password

Table 2. List of SNMP parameters supported by pureLiFi APs.

Please note that the changes done to all the parameters are applied instantly, except for the last two (snmpLiFiEnableROStatistics and snmpLiFiAdmninUserPassword). The latter require the AP to be power cycled for the changes to take effect.

2.5. Remote lamp control

The pureLiFi Management VM also offers lamp control protocol. It is implemented by command line utility (called **vlconf**). It is used to adjust lamp brightness and power level. Unlike the offset current parameters in TR-069 and SNMP, the changes done by this interface will not persist after reboot (i.e. on boot the AP will pick up the settings from either SNMP or TR-069 configuration file). Both multicast and unicast options are available, to run the multicast option use "-M" flag. Example usage is as follows (set brightness to 86% on multicast group 226.1.1.1):

```
$ vlconf -M -b 86 226.1.1.1
```

To see full manual for **vlconf** run it with flag "-h" (or "--help").

pureLiFi ACS offers also a PHP wrapper for vlconf. It enables easy integration with any web interface. The control can be accessed from any device on the network through the web interface at

```
http://10.10.1.15/lifictl.php
```

where 10.10.1.15 represents the IP address of the ACS server

The script shows the results of the commands passed via web address. The allowed commands are:

Command	Description
`lifictl.php?IP=xxx.xxx.xxx.xxx&READ`	Read current settings from AP at ***xxx.xxx.xxx.xxx***
`lifictl.php?IP=xxx.xxx.xxx.xxx&POWER=y`	Set power level to ***y*** on AP at ***xxx.xxx.xxx.xxx***
	Parameter ***y*** values: 0 – Lamp and driver off 1 – Lamp on, digital signal off 2 – Lamp on, digital signal on
`lifictl.php?IP=xxx.xxx.xxx.xxx&DIM=zzz`	Set brightness level ***zzz*** on AP at ***xxx.xxx.xxx.xxx*** ***zzz*** is a brightness level between 0 and 100 [%]

The commands described above could be combined together, e.g. to set power level to 2 and brightness to 86% on AP at 10.10.1.124 a single command can be run:

```
10.10.1.15/lifictl.php?IP=10.10.1.124&POWER=2&DIM=86
```

Figure 3 shows the output after running READ command through the script. Figure 4 shows the example output after running POWER=2 and DIM=86 (set power level to 2 and brightness to 86) command.
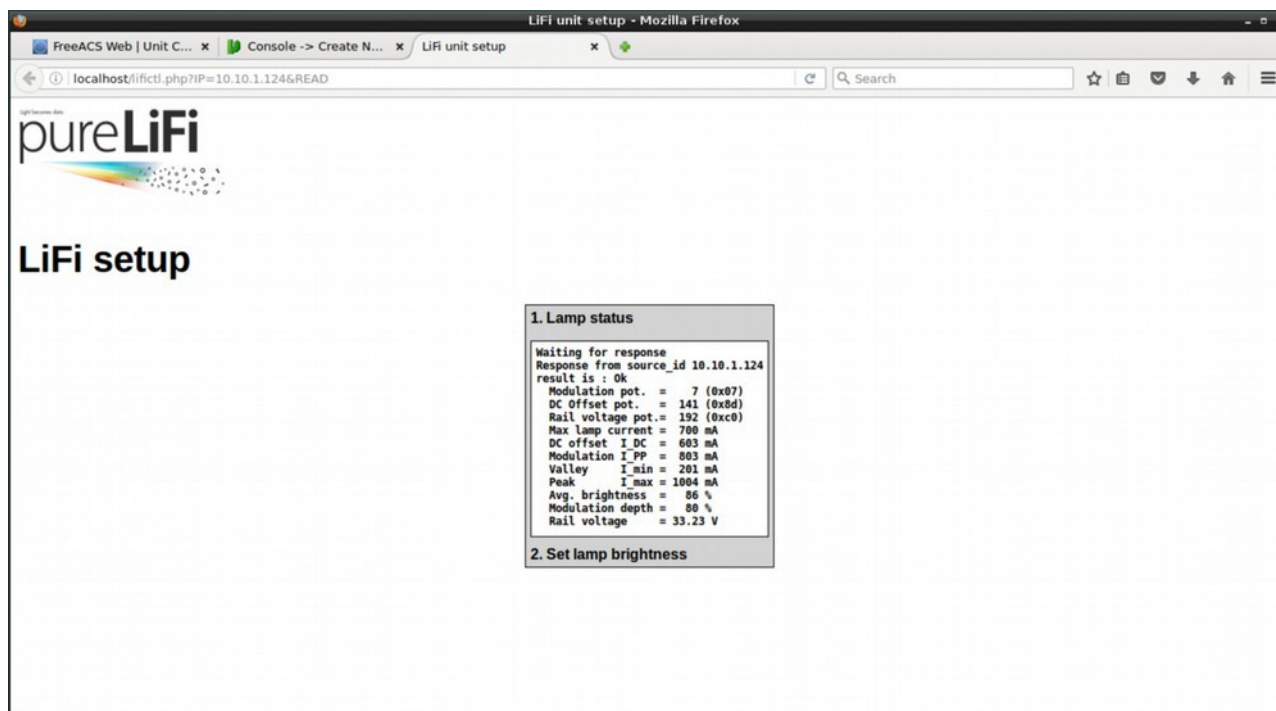
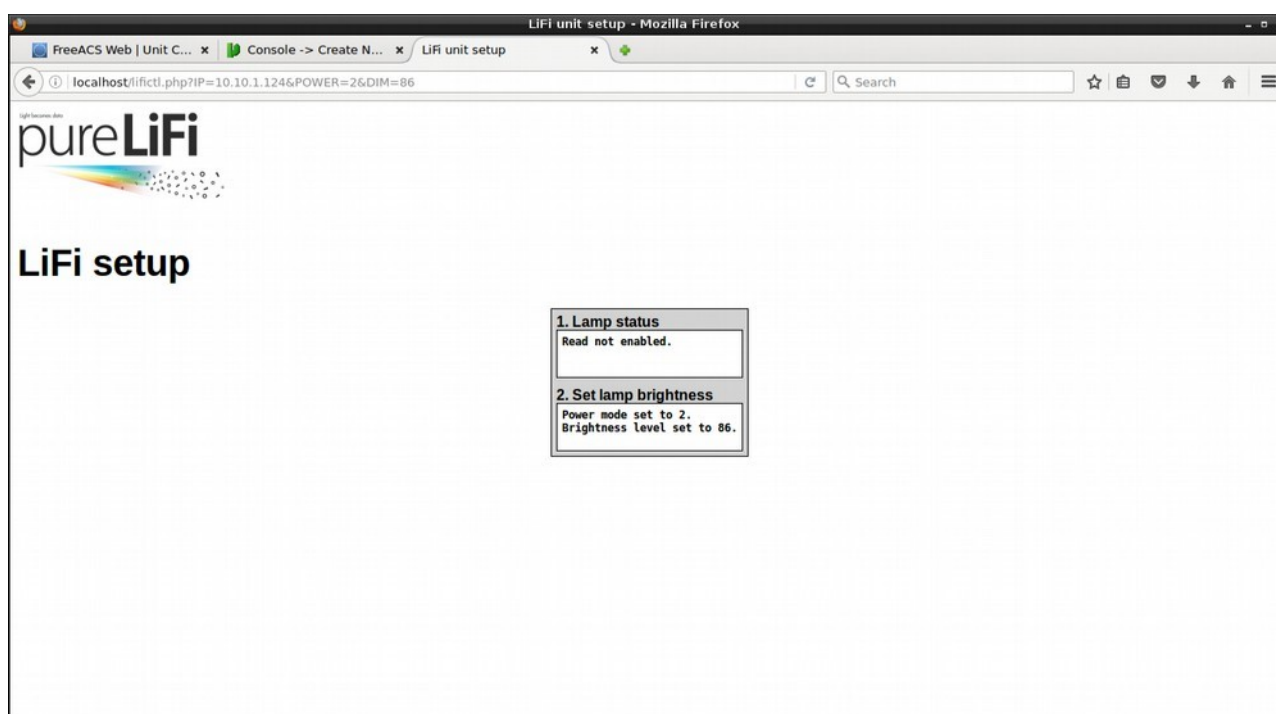Figure 3. Successful read command output.

Figure 4. Successful set power level and brightness command output.

In addition to the tools above, the VM also offers a Web-GUI tool to manage lamp configuration of the AP. The tool can be accessed at:

```
http://10.10.1.15/vlconf.php
```

where 10.10.1.15 represents the IP address of the ACS server

The tool has the same functionality as the two previously described (command line interface binary and web PHP wrapper). The main difference is the Lamp Control Web Interface provides easy to use and intuitive tool to manage lamp settings. The default web interface is shown in Figure 5.
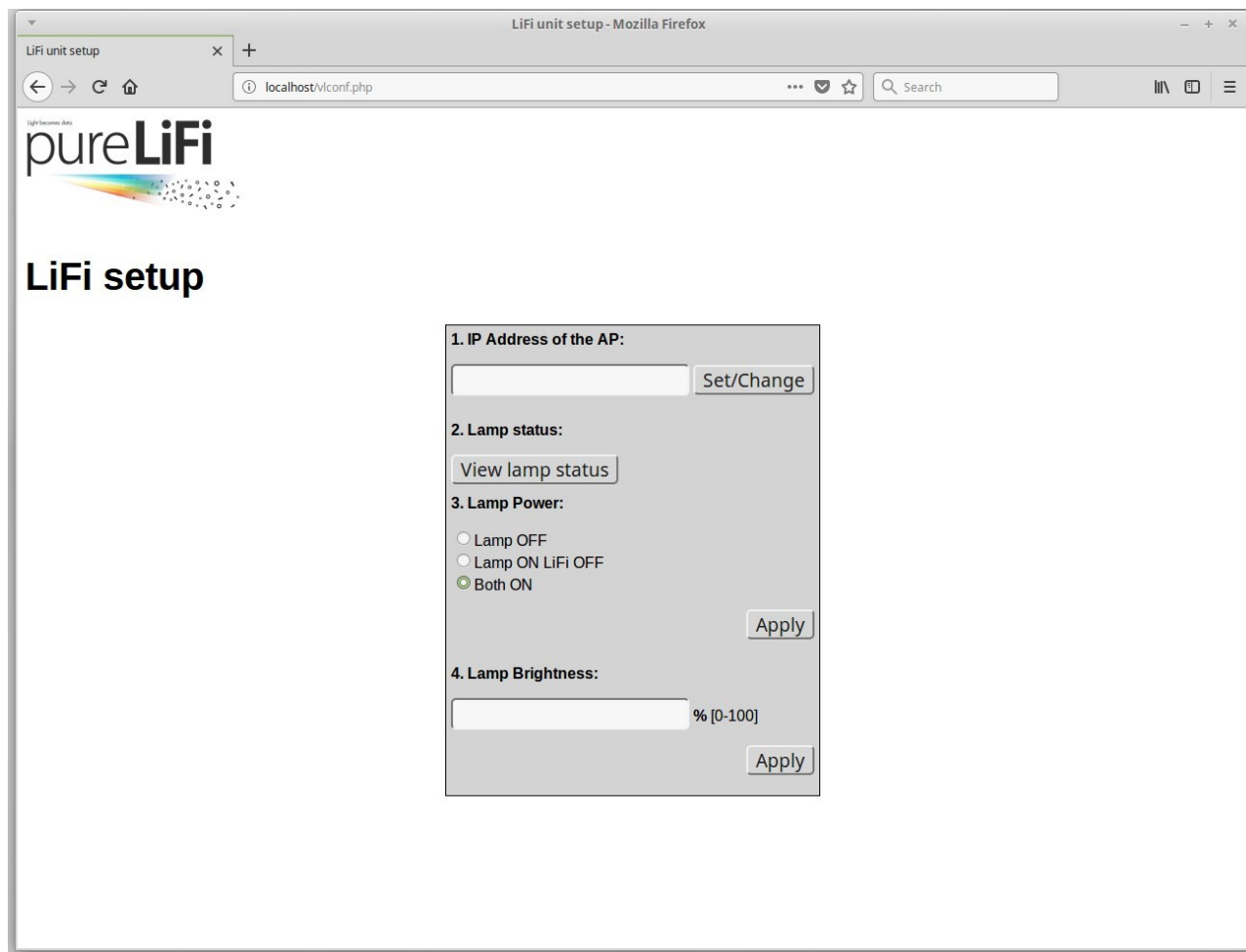

Figure 5. Lamp management Web GUI.

To start using the tool, user must first provide the IP address of the unit or a multicast group (to manage multiple APs at once, lamp status option would not work in this mode). Once that is provided, and "Set/Change" button is pressed, the AP with a given IP can be managed. The provided IP address will be stored until the page is closed or new IP is provided (using the same method as above). Figure 6 shows the Lamp Control Web GUI with AP IP address set to 10.10.1.40.
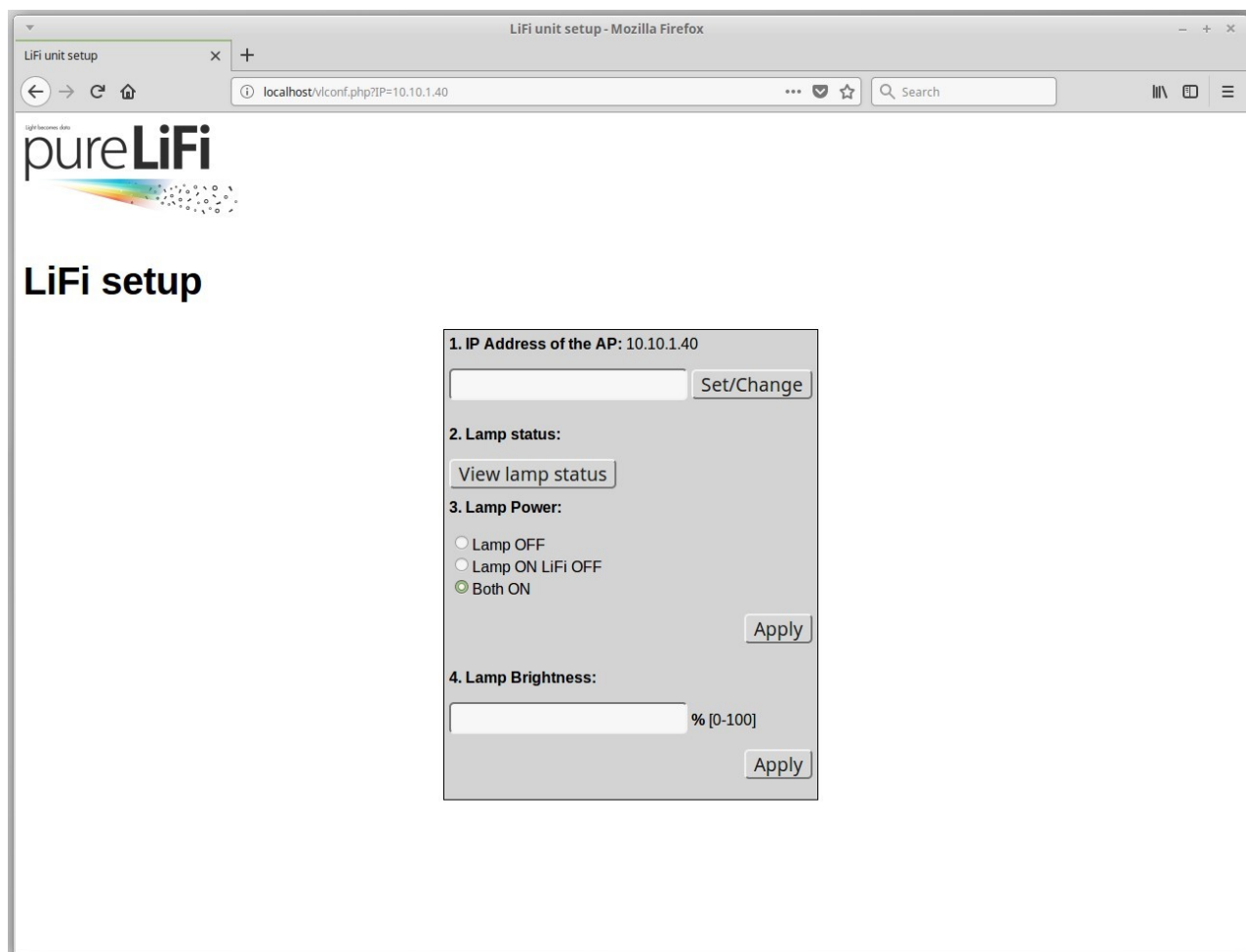
Figure 6. Lamp management Web GUI with AP IP address set.

Now to manage the AP, the operator needs to provide a value and press the button next to the configuration option. Please note, that only one option can be set at one time (i.e. either read or power level or brightness). To power on the lamp and change brightness user needs to issue two commands.

2.6. DHCP Server

pureLiFi-ACS virtual machine has a pre-configured DHCP server installed. The server is disabled by default.

The configuration of DHCP server is located in /etc/dhcp/dhcpd.conf Most important configurations are located at the end of the file, and are as follows:

```
option vlanid code 132 = unsigned integer 16;
option acsip code 235 = ip-address;

subnet 192.168.1.0 netmask 255.255.255.0 {
        range   192.168.1.100     192.168.1.199;

        option subnet-mask        255.255.255.0;
        option broadcast-address 192.168.1.255;
        option routers            192.168.1.15;

        option time-offset        3600;         # (UTC+1)
#       option vlanid             99;           # For future use
        option acsip              192.168.1.15;  # IP of the ACS
}
```

User may need to adjust that file, for the correct operation of the overall system. Please make sure the following:

1. ACS IP address is set statically, as described in Section 2.1.1 and is on the same subnet as the one specified in dhcpd.conf
2. Custom DHCP Tag 235 is specified as acsip and option acsip is set to the IP of the ACS (to ensure APs detect the ACS IP address correctly)
3. To run DHCP server once please run: ***sudo service isc-dhcp-server start***
4. To enable DHCP server to run on boot please run: ***sudo update-rc.d isc-dhcp-server enable*** (***disable*** to disable DHCP server from running on boot)

2.7. SSH access to the APs

LiFi Access Points offer a limited access over SSH protocol. The main functions supported by the APs are the following:

* Lamp management (using lifictl binary – a local version of vlconf (see chapter 2.5.))
* Firmware upgrade (alternative to ACS method)
* AP debugging
* Forcing AP to look for ACS again (in case the ACS was not detected on boot)

To access the AP over SSH, the user needs to use the following credentials:

Username: lifi

Password: (empty) [type in enter when prompted]

2.7.1. Local lamp management on the AP

When accessing the AP via SSH interface, user can use a build-in binary to change lamp settings. The binary is called *lifictl* and works the same way as *vlconf* binary on the Management VM. The only difference is that *lifictl* can only generate requests for the AP it is running on (i.e. the AP that the user SSH'ed to) and do not support multicast option (and hence it does not require an IP address to be provided). For more information on *lifictl* usage, please run it with *-h* flag when connected to the AP.

2.7.2. Firmware upgrade over SSH

To upgrade the firmware using SSH, the user needs the packed-*.bin file. The process is as follows:

1. Copy the firmware image to the /tmp/ folder on the AP (using SCP)

2. SSH to the AP (as user lifi)

3. Run the following command: ***sudo updatelifi /tmp/packed-*.bin***

4. The AP will now flash new FW and reboot. The command prompt will freeze until the unit is finished updating the FW.

5. Once updated, the unit's status LED will be green and the light will be on. SSH access to the unit will be restored.

2.7.3. AP debugging

The AP stores some log files inside /tmp/log/ directory. The most important are:

- /tmp/log/lightmgmt – logs information, warnings and errors from light management software. Useful when the AP does not power-up completely (i.e. status led is blinking red after boot).

- /tmp/log/poe – logs PoE negotiation with the switch. In case not enough power is allocated (when the LED lamp flashes after startup and the device reboots). In this case it is recommended to disconnect the LED lamp from the Tx Driver Box and power up the AP (removing the lamp will significantly reduce power consumption and hence the AP should boot successfully). Once the AP is on (status LED will be blinking red since no lamp is connected), the user can look inside this file and check if the negotiation process is completed successfully.

2.7.4. Forcing AP to look for the ACS again

In order to force the AP to look for the ACS, user can run the following command: *sudo acs_scan*. The command will report to the operator if the ACS IP has been found or not. However, if the DHCP settings have just been changed (to add tag 235 with the IP of the ACS) it is recommended to power cycle the AP as it usually contacts the DHCP server on boot.