

Design and Implementation of a hardwired/wifi network

Ross Maloney

Revision 1: May 2020

Abstract

A complete network example is presented from requirements, through design, implementation, and testing. A network of hardwired devices is to have access to all devices on that network together with Internet access, although the network itself is isolated from the Internet accessing it. A main network is also to use the same Internet access together with providing DLNA service to the TV connected to it. A WiFi network is also to access this Internet connection together with the network storage of the DLNA. Details of configuration of all devices together with their physical connections are given. Testing of the resulting network is also discussed. The component parts of the network are from multiple manufacturers.

1 Design

1.1 Requirements

Two Mac PC are to be network connected. Each Mac is to share a printer and a Network Address Storage (NAS) device each of which is on the network containing the Macs. This network is to have Internet connection so each of these four devices have Internet access. This network of devices is to be isolated so only the devices physically connected to the network can access the devices on this network. All these devices are hardwire connected via RJ45 ethernet cables.

A separate NAS is to provide DLNA services to a TV which is network connected to the NAS. Access is required by the Macs and NAS of the hardwired network to this second NAS for servicing and backup. The TV is also to have Internet connection through the same Internet service connection used for the hardwired network.

The Internet service connection is also to be accessible by WiFi devices. The second NAS is also to be accessible from these WiFi devices.

1.2 Design overview

Figure 1 shows the overall configuration of the network designed to fulfil the requirements. Table 1 describes each of the hardwired elements included in the diagram.

Three networks are involved in this design. The 192.168.22.0 is the hardwired network. The 192.168.8.0 network is the *mainstream* network providing Internet connection and DLNA services via the Netgear ReadyNAS (NAS 2). This DLNA service is accessible by both the TV connected to

this network and the WiFi network. The third network 192.168.68.0 thw WiFi network formed bt standard Google wireless pods.

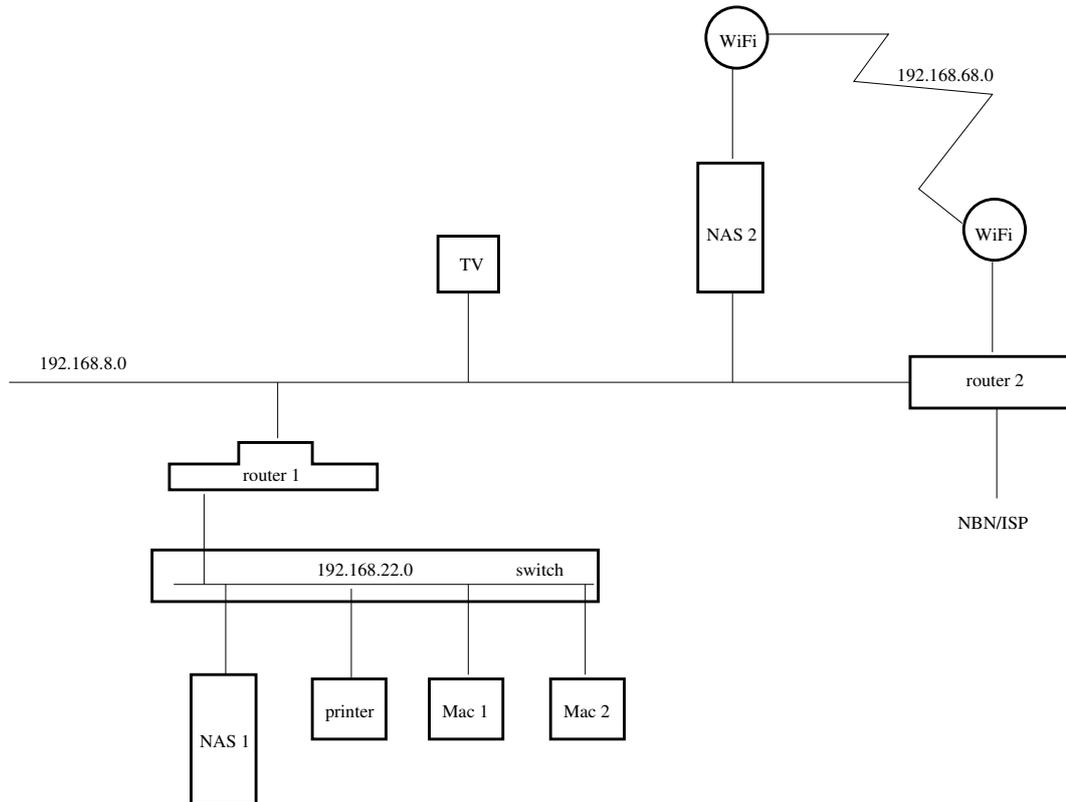


Figure 1: Diagram of the network configuration

Although the Netgear switch has L3 capacity, only it's L2 capacity was used. L2 enables the creation and management of VLANs. Routing between such VLANs is part of the L3 capacity. However, better routing between networks 192.168.22.0 and 192.168.8.0, and protection of those networks, folloed from using separate router (router 1). Networks 192.168.22.0 and 192.168.8.0 were set up using VLANs contained within the switch.

Table 1: Equipment forming the network

Network component	Brand name of hardware
printer	HP Color Laser Jet Pro M252dw
NAS 1	Netgear ReadyNAS RN316 with 6 x 2T Seagate disks
NAS 2	Netgear ReadyNAS RN516 with 6 x 2T Samsung SSDs
router 1	Tp-link TL-ER5120 Gigabit Load Balance Broadband Router
router 2	Cisco RV042G Gigabit Dual WAN VPN Router
switch	Netgear GS724Tv4 24 port Gigabit Smart Switch
mac 1	Apple Mac mini Server (Mid 2011)
mac 2	Apple Mac Pro (Late 2013)
WiFi	Google WiFi Mesh Router
TV	LG LED flat panel TV

Mac 1 and Mac 2 were configured for dual booting of Apple OS X and Debian 9 Linux. Both Macs ran Linux in a command line mode during implementation of this network.

2 Implementation

2.1 Switch

The switch is the foundation of the design. Without the switch functioning correctly, the network fails. This is despite it only holding two VLANs of which only one is used in the operating network.

The switch had a default IP address of 192.168.0.239. Mac 1 was configured to have the address structure:

IP address	192.168.0.7
network mask	255.255.255.0
network address	192.168.0.0
broadcast address	192.168.0.255
gateway address	192.168.0.250
dns-nameserver	8.8.8.8

so it had the same network address as the switch so to configure the switch. The Mac 1 configuration was done by editing the file at `/etc/network/interface` on Mac 1 and then rebooting Mac 1. With an ethernet cable connecting the ethernet port of Mac 1 and port 23 of the switch, the address 192.168.0.239 of the switch was typed into the address bar of the Firefox web browser running on Mac 1. The login page of the switch opened on Firefox. The default password for the switch password was entered into the login page, before the LOGIN button was clicked. The System window of the switch then appeared.

From the System window, the click sequence:

Switching → VLAN

brought up the VLAN Configuration window of the switch. The table contained on that window indicated 3 VLANs already configured on the switch. Two additional VLANs were added to this list. Into the VLAN ID window at the top of the table showing the VLANs, the number 8 was typed as the ID of a new VLAN. Then into the VLAN Name window mainstream was typed. Then the ADD button at the bottom right of the screen was clicked. The new VLAN 8 appeared at the bottom of the VLAN Configuration table. This process was repeated for a second VLAN with ID 22 and named hardwired.

The Advanced item in the selection menu in the top left of the screen was clicked which brought up another selection menu replacing the first. The VLAN Membership item was clicked from this menu which brought up the VLAN Membership window. From the drop down menu list labelled VLAN ID in the top left of this table, the VLAN ID 8 was clicked which brought up the screen showing the switch ports assigned to VLAN 8. Since at this stage none had been assigned, all 26 patches in the membership display were blank. Switch ports 1 to 6 were to be part of VLAN 8. So the patch under 1 to 6 in the VLAN Membership table were clicked twice; the first clicked brought up a T in the patch, the second click brought up the required U. Then the APPLY button at the bottom right of the screen was clicked. Then 22 was selected from the VLAN ID drop down menu. Switch ports 7 to 22 were to form VLAN 22. So the patches under items 7 to 22 were double clicked before the APPLY button clicked. Then VLAN 1 was selected from the VLAN ID drop down list. This showed a U under items 1 to 26 indicating those external ports of the switch were connected to VLAN 1. This should not be the case. So the patch under items 1 to 22 were clicked until each showed a blank. Items 23 to 26 retained their U. The APPLY button was then clicked. At this stage the external ports of the switch had been assigned to the internal VLANs in the switch. Each switch port was assigned to a single VLAN. Note: Mac 1 which was used to configure the switch was connected to VLAN 1 which was the default VLAN of the switch.

Then the `Port PVID Configuration` entry in the selection menu in the top left of the window was clicked which brought up the `Port PVID Configuration` window. The little patch on the left against `g1` through `g6` were clicked. This produced a tick mark in the patch when it was clicked and coloured the corresponding row in the table orange. Then `8` was typed into the `Configured PVID (1 to 4093)` entry field and the `APPLY` button at the bottom right of the screen was clicked. This was repeated for `g7` through `g23` using `22` in the `Configured PVID` field.

At this stage configuration of the switch was complete. Mac 1 was then logged out of the switch and the ethernet cable between Mac 1 and the switch removed.

2.2 Router 1

The default address of router 1 was `192.168.0.1`. The ethernet cable of Mac 1 was connected to port 23 of the switch. No change to the Mac 1 networking address structure was needed for router 1 had the same default network address as the switch – not the same IP address, but the same network address.

When address `192.168.0.1` was entered into the address field of the Firefox web browser running on Mac 1, a window appeared from router 1 requesting the creation of an administrator account on the router. The user name `admin` and the password `password` were used for this account. They were entered into the corresponding fields on the window, and the `Confirm` button clicked. A login window then appear, and the user name and password of the created account were entered into the corresponding fields, before the `Log In` button was clicked. The `System Status` window of router 1 then appeared.

From the `System Status` screen, the click sequence:

`Network` → `WAN` → `WAN1`

was used to display the `WAN1 Connection Configuration` screen. From the `Connection Type` drop down menu, `Static IP` was clicked. This resulted in a modification to the original `Connection Configuration` screen. Into the `IP Address` field of this modification screen `192.168.8.250` was entered and `255.255.255.0` into the `Subnet Mask` field. The `Default Gateway` field was set to `192.168.8.248`. Then the `Save` button at the bottom left of the screen was clicked.

The click sequence:

`Network` → `LAN`

was then entered which produced the `LAN` screen. The `192.168.0.1` entry in the `IP Address` field was changed to `192.168.22.250`, the new address for router 1. Then the `Save` button at the bottom left of the screen was clicked. This address was on the hardwired network which made route 1 as the path between the hardwired and the mainstream networks. All devices on the hardwired network used this router 1 address as their gateway address. By changing the LAN address, connection with router 1 from Mac 1 was lost.

2.3 Router 2

Router 2 was the sole Internet access for the total network. This hardware had a default IP address of `192.168.1.1`. So Mac 1 was configured to have the address structure:

IP address	192.168.1.7
network mask	255.255.255.0
network address	192.168.1.0
broadcast address	192.168.1.255
gateway address	192.168.1.250
dns-nameserver	8.8.8.8

so it was on the same network address as router 2 was as to use it to configure router 2. This was done by editing the file `/etc/network/interface` on Mac 1 and then rebooting Mac 1. The other end of the ethernet cable connected to Mac 1 was connected to LAN port 1 of router 2. Into the address field of the Firefox web browser running on Mac 1 the address `192.168.1.1` of router 2 was entered resulting in the login screen of router 2 appearing. The default user name `admin` and password `admin` were entered to gain access to router 2. The `Setup` item in the menu on the left-hand side of the screen was clicked. Into the `Device IP Address` field the address `192.168.8.248` was entered. The `Subnet Mask` and `WAN Settings` were left at their default values. The `SAVE` button at the bottom left of screen was then clicked. Connection between Mac 1 and router 2 was lost as a result of this address change.

2.4 WiFi

Two WiFi routers were used to connect one device each to create the wireless network to enable iPhone and iPad access to those devices. These routers create and then lock into a WiFi network with address `192.168.68.0`. How to change this network address was unknown.

Each WiFi router was connected via an ethernet cable to its LAN connection at the base of the router. The other end of the cable was connected to a LAN socket on the device which the WiFi router was to link to the WiFi network. One WiFi router connected to NAS 2 and the other to router 2.

The Google home WiFi app implemented on an iPhone Xs was used to configure each WiFi router. First the WiFi and router 2 combination was set up. Configuration started by pressing the *four-layer stack* symbol at the top left-hand side of the app. From the options presented in the drop down menu which resulted, `Set up WiFi point` was selected. After starting this option, `Creat new network` was selected from the options which followed. The `NEXT` button at the bottom of the app screen was then pressed. Each of the following steps of the app needed the `NEXT` button at the bottom right of the screen to be pressed. The `Looking for your device` took minutes to perform its function. To register the WiFi router, the app used the camera on the iPhone to scan the QR on the base of the WiFi router. When asked by the app, the network name was set as `yenolamat2` and a password set for the WiFi network. The app then connected the WiFi router to the WiFi network created and tested that it performed correctly.

This procedure was repeated for the WiFi router and NAS 2 combination. It was done after NAS 2 had been configured (see below). In this case, since the network had been created, attaching of the WiFi device to the existing WiFi network was selected in the app. No network naming or password setting was part of this second device configuration.

2.5 NAS 2

NAS 2 had a default address of `192.168.1.1` which was the same as the default address of router 2. Thus no change to the network address structure of Mac 1 was required after configuring router 2. The other end of the ethernet cable attached to Mac 1 was attached to the left-hand ethernet port on the back of NAS 2. NAS 2 knows this left-hand port as `eth0` and the right-hand port as `eth1`.

Entering the address 192.168.1.1 into the Firefox web browser address field brought up the login window of NAS 2. The default user name and password of admin and netgear1 respectively gained access to NAS 1 which then displayed it's System window. A click on the Network entry in the options across the top of that screen gave access to the two network interfaces available. A click on the gear wheel symbol next to eth1 gave a selection menu. By clicking Settings in that menu, the configuration window for eth1 opened. By clicking IPv4 from the options across the top of this window, the required window for configuring eth1 appeared. The Address field was set to 192.168.68.106 and the Router field set to 192.168.68.1 (these addresses are associated with the WiFi network yet to be configured). Then the Apply button at the bottom of the screen was clicked. A similar approach was followed to eth0. In the case of eth0 the Address field was set to 192.168.8.106 and the Router field set to 192.168.8.248. When the Apply button was clicked, communication between Mac 1 and NAS 1 was lost. So the order eth1 then eth0 was important.

The resident ReadyDLNA app in the System → Settings folder was activated.

2.6 NAS 1

NAS 1 had a default address of 192.168.1.1 which is the same as default address of router 2. Thus no change to the address structure of Mac 1 was required.

Configuring NAS 1 was similar to that described above for NAS 2. For NAS 1 only one of the two ethernet interfaces of the device was used. Here eth1 was chosen to be used. Into the eth1 setting Address field 192.168.22.112 was inserted and 192.168.22.250 into the Router field. Communication between Mac 1 and NAS 2 was lost when the Apply button was clicked.

2.7 Printer

The network address of the printer was set using the small touch-screen on the printer. The address of the printer was set to 192.168.22.31 and the router set to 192.168.22.250.

2.8 Connecting it together

RJ45 ethernet cables were used to connect all the components into a network. The connections to the switch were:

Device	Switch port
printer	23
Mac 1	11
Mac 2	9
NAS 1 eth0	5
NAS 1 eth1	
NAS 2 eth1	17
router 1 LAN	21
router 1 WAN	2
router 2 LAN	4

Routers 1 moved network packets between subnets through the switch. It was also necessary to configure the devices physically connected to the network so they performed as expected.

In both Mac 1 and Mac 2 the file `/etc/network/interface` was edited to have the address parameters shown in Table 2. This address combination defined not only the IP address of the device but also the device which handled the next hop (gateway) off the network the device was physically housed on. Then the file `/etc/resolv.conf` was edited to contain the line `nameserver 192.168.8.248`. This entry meant a web address such as `www.google.com.au` was successfully translated into the IP address associated with it in the wider Internet space. Without such an entry, the address `8.8.8.8` could be pinged but not `www.google.com.au`.

Table 2: Network configuration of connected devices

Addresses	Mac 1	Mac 2	NAS 1 eth1	NAS 2 eth0	NAS 2 eth1
IP	192.168.22.7	192.168.22.9	192.168.22.112	192.168.8.106	192.168.68.106
network mask	255.255.255.0	255.255.255.0	255.255.255.0	255.255.255.255	255.255.255.0
network	192.168.22.0	192.168.22.0	192.168.22.0	192.168.8.0	192.168.68.0
broadcast	192.168.22.255	192.168.22.255	192.168.22.255	192.168.8.255	192.168.68.255
gateway	192.168.22.250	192.168.22.255	192.168.22.250	192.168.8.248	192.168.68.1
dns-nameserver	8.8.8.8	8.8.8.8	8.8.8.8	8.8.8.8	8.8.8.8

The WAN connection of router 2 was connected to the NBN Internet service. That service was a 100Mb/sec download and 40Mb/sec upload service. One LAN port was connected to the switch while another was connected to an RJ45 ethernet port on the back of the TV.

3 Testing

Mac 1 was able to successfully ping Mac 1, Mac 2, the printer, NAS 1 eth1, and address 8.8.8.8 (which was on the Internet). Mac 2 successfully pinged the same devices. Access to the Internet by both Mac 1 and Mac 2 was tested by successfully pinging the address `www.google.com.au`. Both Mac 1 and Mac 2 pinged NAS 2 eth0 (192.168.8.106) successfully.

The speed of the Internet connection was tested using using two approaches. One approach used the Firefox web browser running on Mac 1. The file `1000meg.test` from URL `ftp.iinet.net.au/test` was downloaded, with the speed 10.5 MBytes/sec shown by Firefox. The second approach was by using `Network check` item on the Google iPhone app used to install the WiFi. The Internet speed of your home gave a download speed of 94Mbps and an upload speed of 34Mbps. Since the Internet connection was by NBN using an account having a nominal connection download speed of 100Mb/sec, these results were good. This download passed through two routers (1 and 2). Those router appeared not to slow the download speed.

Mac 1 was reconfigured to operate on the mainstream subnet by editing it's `/etc/network/interface` file to contain:

```
IP address      192.168.8.7
network mask    255.255.255.0
network address 192.168.8.0
broadcast address 192.168.8.255
gateway address 192.168.8.248
dns-nameserver  8.8.8.8
```

and connecting the ethernet cable from it to port 1 on the switch. Mac 1 was then rebooted. In this mode it could not ping the printer (192.168.22.31), Mac 2 (192.168.22.9), NAS 2 eth1 (192.168.22.112), nor the WAN port of router 1 (192.168.8.250). This indicated the hardwired network (192.168.22.0) was isolated. It could ping NAS 1 eth0 (192.168.8.106) and the LAN

port of router 2 (192.168.8.248), but not NAS 2 eth1 (192.168.68.106). From Firefox operating on Mac 1, the 1000meg.test file was downloaded from the URL ftp.iinet.net.au/pub/test at a speed of 10.5MB/sec. So the mainstream subnet (192.168.8.0) was operating as expected.

Both Mac 1 and Mac 2 were booted into OS X mode. Safari access to a number of web sites was obtained using both Macs.

The VLC app was loaded onto both an iPhone Xs and a iPad Pro, both of which were connected to the yenolamat2 WiFi network. In both cases the app operated successfully on the files contained on NAS 2.

From the TV, DLNA was operated using the NAS 2 files.