

Design and Implementation of a hardwired/wifi network

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Abstract

A complete network example is presented from requirements, through design, implementation, and testing. A network of hardwired devices are 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 which are on the network containing the Macs. This network is to have Internet connection so each of these four devices can 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 the 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 updating. 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 which does connection to the Internet but also provides DLNA services to the TV attached to it using the attached Netgear ReadyNAS (NAS 2). The third network 192.168.68.0 is a WiFi network formed from a standard Google wireless router (router 3).

Although the Netgear switch has L3 capacity, only it's L2 capacity was used here. L2 enables the creation and management of VLANs. Routing between such VLANs is part of the L3 capacity. However,

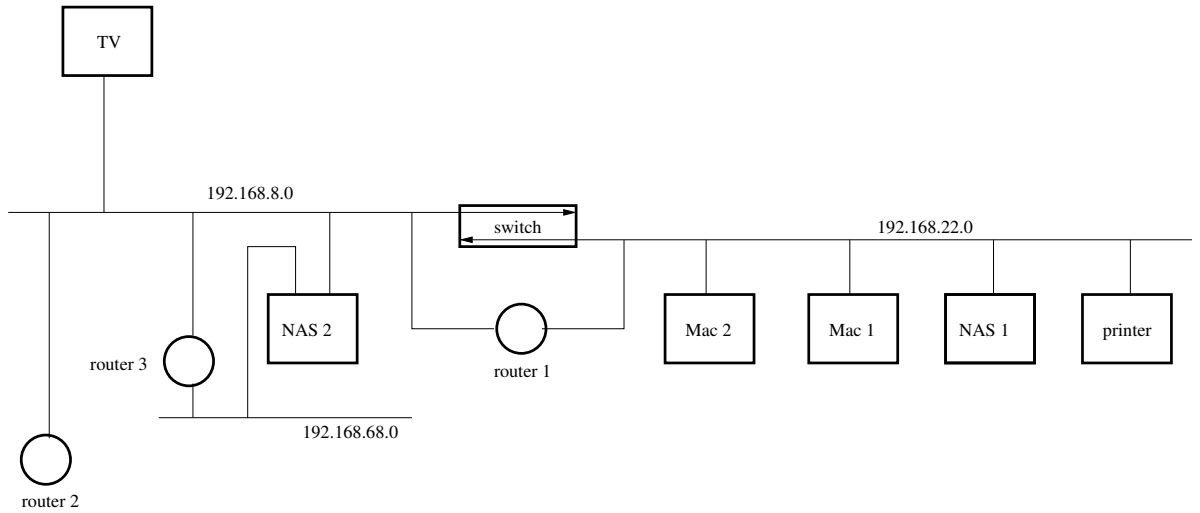


Figure 1: Diagram of the network configuration

that manner of VLAN routing is not appropriate here. Networks 192.168.22.0 and 192.168.8.0 were 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
router 3	Google model AC-1304 Home Wi-Fi Solution
switch	Netgear GS724Tv4 24 port Gigabit Smart Switch
mac 1	Apple Mac mini Server (Mid 2011)
mac 2	Apple Mac Pro (Late 2013)
TV	LG LED flat panel

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

2 Implementation

2.1 Switch

The switch is the more important element in the design. Without the switch functioning correctly, the network fails. This is despite it only holding two VLANs used in the 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 it could configure the switch. This configuration was done by editing the file at `/etc/network/interface` 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. Then 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. 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 name `hardwired`.

The `Advanced` item in the selection menu in the top left of the screen was clicked which brought up another selection menu which replaced 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, so 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 and then 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` enter 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. So Mac 1 was logged out of the switch.

2.2 Router 1

The default address of router 1 was `192.168.0.1`. The ethernet cable connecting port 23 of the switch was move to the LAN port of the router while the other end remained connected to Mac 1. No change

to the Mac 1 networking address structure was necessary since 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, and the `Confirm` button clicked. A login window then appear, and the user name and password of the created account was entered into the corresponding fields, before the `Log In` button was clicked. The `System Status` iwindow 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 modified 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 enter in the IP Address field was changed to 192.168.22.250. Then the `Save` button a the rotton left of the screen was clicked. This was the address on the hardwired network which would route between the hardwired and the mainstream networks. The manufacturer's documentation for the router suggests this gateway address be the same as the address of the device. By changing this LAN address, connection with router 1 from Mac 1 was lost.

2.3 router 2

Router 2 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 for it to configure router 2. This was done by editing the file `/etc/network/interface` and then rebooting Mac 1. The other end of the ethernet cable connected to Mac 1 was was connected to the 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. The default user name of `admin` and password of `admin` were entered to gain access to router 2. The `Setup` item in the menu on the left-hand size 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 router 3

Router 3 is a WiFi device with one RJ45 WAN and one RJ45 LAN connection. As with most WiFi devices, the hardware LAN port was on the WiFi network it generates.

The WAN and LAN jacks of router 3 were on it's base. The LAN jack was connected by an RJ45 ethernet cable to the `eth1` of NAS 1 and the WAN port connected to port 4 of the switch. It was necessary that router 3 had access to the Internet before configuration was attempted. When the device had located the Internet, the red coloured light showing from router 3 changed to white.

Router 3 was configured using the Google WiFi App downloaded from the Apple App Store and run on a iPhone Xs. A WiFi network with the name `Georgie66` was created using this app. Once installation of the WiFi on router 3 was complete, the iPhone used for this installation and a iPad were connected to this WiFi network using the WiFi portion of the standard `Settings` app on those devices. The information part of that app indicated the WiFi network `Georgie66` created had the network address `192.168.68.0`. Membership of this network address was used in configuring NAS 1 (see below).

2.5 NAS 1

NAS 1 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 address of Mac 1 was required. The other end of the ethernet cable attached to Mac 1 was attached to the left-hand ethernet port on the back of NAS 1. NAS 1 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 1. 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 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 applied 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 2

NAS 2 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 of Mac 1 was required.

Configuring NAS 2 is similar to that described above for NAS 1. For NAS 2 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	3
router 3 WAN	4

Routers 1, 2, and 3 move 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. NAS 1 eth1 was connected to router 3, not the switch.

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 2 eth1	NAS 1 eth0	NAS 1 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 2 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 1 eth0 (192.168.8.106) successfully.

The speed of the Internet connection was tested using 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. Since the Internet connection was by NBN using an account having a nominal connection download speed of 100Mb/sec, this result was good. This download passed through two routers (1 and 2). Those routers appeared not to slow the download speed.

Mac 1 was reconfigured to operate on the mainstream subnet by editing its `/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 1 eth1 (192.168.8.106). 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 PlayerXtreme was loaded onto both an iPhone Xs and a iPad Pro, both of which were connected to the Georgie66 WiFi network. In both cases the app operated successfully on the files contained on NAS 1.

From the TV, DLNA was operated using the NAS 1 files.