A Note on New Packet Radio (NPR) as backup up-link with automatic failover via OSPF

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Abstract

This note reports on an experiment exploring the feasibility of using a pair of NPR Master/Client modems as a narrow-band backup link between a LAN gateway and Internet when the primary broadband up-link fails. We demonstrate how the NPR modems can be used to route transit traffic beyond the gateways and that the link can be used for automatic OSPF-based fail-over routing.

1. Background

AMPRNet Sweden [1] has the ambition to provide an infrastructure facilitating making ICT resources, services and applications of the amateur radio community available to society in extraordinary situations as an extra lifeline when regular systems are non-existent or insufficient. This is accomplished by establishing, operating and maintaining redundant links and power systems on a voluntary basis.
Typical radio amateur services, such as voice communication, text messaging/chatting, email and aprs tracking have moderate demands on data transfer rates. So, when fiber-based broadband data links become unavailable to connect local area networks to Internet, radio-based narrow-band data links over radio using lower frequency bands not requiring line-of-sight can still be very useful as backup and are definitely better than nothing.
Traditionally, radio amateur data communication services on HF, VHF and UHF frequencies have been using the ax25 Packet Radio protocol offering data transfer rates in the interval 300-9600 bps interval, which is too low for many applications.
This note is about using the New Packet Radio protocols [2,3] developed by F4HDK as a backup connection between an Ethernet-based LAN gateway and the Internet. This technology offers data rates in the interval 10-500 kbps depending on how much bandwidth you use. The higher data transfer rates are potentially very useful and we are now in the process of testing the use of this technology in more detail.

2. Experiment design

The purpose of the experiment described in this note is designed to demonstrate the feasibility of using an 100 kbps NPR link as a narrow-band backup link to a broadband 1Gbps fiber-based Internet connection including OSPF-based automatic fail-over. The network topology is illustrated in Fig.1 below.

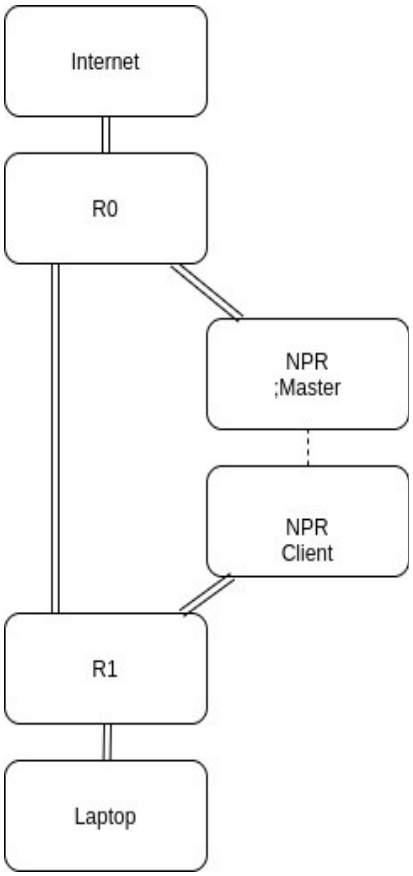

Fig.1 Using an NPR Master/Client pair as backup upstream link

3. Test bed

The routers used , R0 and R1, are two identical Ubiquiti ER-X sfp routers [4] running EdgeOS [5]. The NPR nodes each includes an NPR70 modem from Elektrokitsorparts [6] configured for remote control, a RaspberryPi running Raspbian as remote controller [7] and a VR-P25D power amplifier [8].

4. NPR Modem configuration

Below we list the configuration files and the results of the **status** and **who** commands when operating. The RaspberryPi's used as remote controllers both have a basic Raspian Buster configuration with the text-based serial communication program minicom added to access the modems via their USB ports.

Master configuration

ready> display config
CONFIG:
  callsign: 'sa0bxi'
  is_master: no
  MAC: 4E:46:50:52:36:F9

```
  frequency: 433.800MHz
  freq_shift: 0.000MHz
  RF_power: 127
  modulation: 21
  radio_netw_ID: 10
  radio_on_at_start: yes
  telnet active: yes
  telnet routed: yes
  modem_IP: 10.4.2.220
  netmask: 255.255.255.0
  IP_begin: 10.4.2.200
  client_req_size: 2
  DHCP_active: yes
ready> status
   1 status: connected TA:0.0km Temp:28degC
   RX_Eth_IPv4 26674 ;TX_radio_IPv4 15963 ; RX_radio_IPv4 17220
   DOWNLINK - bandwidth:0.0 RSSI:-54.6 ERR:0.00%
   UPLINK -   bandwidth:0.0 RSSI:-35.0 ERR:0.00%
CTRL+c to exit...
ready> who
1 Master: ID:127 Callsign:sa0bxi
ME: Callsign:sa0bxi ID:0 modem IP:10.4.2.220
Clients:
 ID:0 Callsign:sa0bxi IP start:10.4.2.200 IP end:10.4.2.201
CTRL+c to exit...
ready>
```

Client configuration

```
ready> display config
CONFIG:
  callsign: 'sa0bxi'
  is_master: no
  MAC: 4E:46:50:52:36:F9
  frequency: 433.800MHz
  freq_shift: 0.000MHz
  RF_power: 127
  modulation: 21
  radio_netw_ID: 10
  radio_on_at_start: yes
  telnet active: yes
  telnet routed: yes
  modem_IP: 10.4.2.220
  netmask: 255.255.255.0
  IP_begin: 10.4.2.200
  client_req_size: 2
  DHCP_active: yes
ready> status
   1 status: connected TA:0.0km Temp:28degC
```

```
   RX_Eth_IPv4 26674 ;TX_radio_IPv4 15963 ; RX_radio_IPv4 17220
   DOWNLINK - bandwidth:0.0 RSSI:-54.6 ERR:0.00%
   UPLINK -   bandwidth:0.0 RSSI:-35.0 ERR:0.00%
CTRL+c to exit...
ready> who
1 Master: ID:127 Callsign:sa0bxi
ME: Callsign:sa0bxi ID:0 modem IP:10.4.2.220
Clients:
 ID:0 Callsign:sa0bxi IP start:10.4.2.200 IP end:10.4.2.201
CTRL+c to exit...
ready>
```

5. Router configuration

The router R0 has an upstream Interface connected to Internet via tunnel tun0 to Amprnet Sweden and the gateway address 44.140.4.1. The router R1 has a downstream interface numbered 44.140.4.249/29 to which a laptop is connected at 44.140.4.251. During the experiment, all these interfaces are reachable from Internet.

R0 and R1 are interconnected via two links, the NPR radio link and a wired link via a local LAN.

According to [3], NPR carries IPv4 packets encapsulated in a customized radio frame, unicast only. Since we need to pass OSPF Hello messages to the multicast address 224.0.0.5, we use the modem subnet (10.4.2.0/24) to tunnel all transit traffic using the ip-ip tunneling protocol. The NPR gateway address (10.4.2.1) and the NPR modem address (10.4.2.200) are used as the remote and local addresses defining the tunnel. This link is called tun1. For the transit link, we have selected the network 10.4.3.0/31. All parameters in the tunnel definitions of both tun1 endpoints are listed below.

For the purpose of isolating the experiment from other traffic on the LAN, the wired link is also encapsulated in a gre-tunnel called tun2 with adresses 10.4.1.0/31

Router 0

```
user@R0:~$ show interfaces
Codes: S - State, L - Link, u - Up, D - Down, A - Admin Down
Interface    IP Address                S/L  Description
---------    ----------                ---  -----------
eth0         wan-address               u/u
eth1         lan-address               u/u
eth2         44.140.4.1/25             u/u  ampr4
eth3         10.4.2.1/24               u/u  npr gateway
tun0         10.4.0.1/30               u/u  amprgw
tun1         10.4.3.0/31               u/u  npr-tunnel
tun2         10.4.1.0/31               u/u
```

user@R0:~$ show interfaces tunnel tun1
tun1@NONE: <POINTOPOINT,MULTICAST,NOARP,ALLMULTI,UP,LOWER_UP> mtu 1480 qdisc noqueue state UNKNOWN group default qlen 1000
link/ipip 10.4.2.1 peer 10.4.2.200
inet 10.4.3.0/31 scope global tun1
Description: npr-tunnel

eth1, eth2, tun1 and tun2 are defined as OSPF interfaces. tun1 has a higher cost than tun2 assigned. Connected networks are distributed.

Router 1

user@R1:~$ show interfaces
Codes: S - State, L - Link, u - Up, D - Down, A - Admin Down

Interface	IP Address	S/L	Description
eth0	lan-address	u/u	
eth1	10.4.2.200/24	u/u	npr modem address
eth2	44.140.4.249/29	u/u	R1 downstream interface
tun1	10.4.3.1/31	u/u	npr-tunnel
tun2	10.4.1.1/31	u/u	testtun2

user@R1:~$ show interfaces tunnel tun1
tun1@NONE: <POINTOPOINT,MULTICAST,NOARP,ALLMULTI,UP,LOWER_UP> mtu 1480 qdisc noqueue state UNKNOWN group default
link/ipip 10.4.2.200 peer 10.4.2.1
inet 10.4.3.1/31 scope global tun1
Description: npr-tunnel

eth1, eth2, tun1, tun2 are defined as OSPF interfaces. tun1 has a higher cost than tun2 assigned. Connected networks are distributed.

6. Validation

After configuration of all units. The functionality is tested with ping, traceroute, routing tables and checking lists of ospf interfaces and neighbors with both the wired and NPR links connected (tun1 and tun2).

Case1: Both tun1 and tun2 are up

Traceroute from Internet to laptop via R0 and R1 shows that tun2 is selected

user@amprnet:~$ traceroute 44.140.4.251
traceroute to 44.140.4.251 (44.140.4.251), 30 hops max, 38 byte packets
1 44.140.1.23 (44.140.1.23) 8.261 ms 0.521 ms 0.372 ms
2 10.4.0.1 (10.4.0.1) 6.787 ms 6.824 ms 7.411 ms
3 10.4.1.1 (10.4.1.1) 6.648 ms 10.120 ms 6.622 ms
4 44.140.4.251 (44.140.4.251) 7.132 ms 7.544 ms 122.485 ms

user@R0:~$ show ip ospf neighbor
Total number of full neighbors: 3
OSPF process 0 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
44.140.1.23	1	Full/ -	00:00:34	10.4.0.2	tun0	0
44.140.4.249	1	Full/ -	00:00:31	10.4.1.1	tun2	0
44.140.4.249	1	Full/ -	00:00:40	10.4.3.1	tun1	0

user@R1:~$ show ip ospf neighbor
Total number of full neighbors: 2
OSPF process 0 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
44.140.4.1	1	Full/ -	00:00:34	10.4.1.0	tun2	0
44.140.4.1	1	Full/ -	00:00:32	10.4.3.0	tun1	0

Case2: tun1 up but tun2 disconnected

When disconnecting the wired connection tun2, an ongoing ping from Internet to laptop at 44.140.4.251 shows that all traffic stops for 50 seconds before it resumes via tun1.
user@amprnet:~$ ping 44.140.4.251
PING 44.140.4.251 (44.140.4.251) 56(84) bytes of data.
64 bytes from 44.140.4.251: icmp_req=1 ttl=61 time=231 ms
64 bytes from 44.140.4.251: icmp_req=2 ttl=61 time=761 ms
64 bytes from 44.140.4.251: icmp_req=3 ttl=61 time=7.15 ms
64 bytes from 44.140.4.251: icmp_req=4 ttl=61 time=173 ms
64 bytes from 44.140.4.251: icmp_req=5 ttl=61 time=55.5 ms
64 bytes from 44.140.4.251: icmp_req=6 ttl=61 time=7.18 ms
64 bytes from 44.140.4.251: icmp_req=7 ttl=61 time=113 ms
64 bytes from 44.140.4.251: icmp_req=8 ttl=61 time=291 ms
64 bytes from 44.140.4.251: icmp_req=9 ttl=61 time=173 ms
64 bytes from 44.140.4.251: icmp_req=10 ttl=61 time=7.67 ms
64 bytes from 44.140.4.251: icmp_req=11 ttl=61 time=231 ms
64 bytes from 44.140.4.251: icmp_req=12 ttl=61 time=447 ms
64 bytes from 44.140.4.251: icmp_req=13 ttl=61 time=290 ms
64 bytes from 44.140.4.251: icmp_req=14 ttl=61 time=172 ms
64 bytes from 44.140.4.251: icmp_req=15 ttl=61 time=54.5 ms
64 bytes from 44.140.4.251: icmp_req=16 ttl=61 time=230 ms
64 bytes from 44.140.4.251: icmp_req=17 ttl=61 time=112 ms
64 bytes from 44.140.4.251: icmp_req=18 ttl=61 time=7.34 ms
64 bytes from 44.140.4.251: icmp_req=19 ttl=61 time=491 ms
64 bytes from 44.140.4.251: icmp_req=20 ttl=61 time=67.0 ms
64 bytes from 44.140.4.251: icmp_req=70 ttl=61 time=376 ms
64 bytes from 44.140.4.251: icmp_req=71 ttl=61 time=256 ms
64 bytes from 44.140.4.251: icmp_req=72 ttl=61 time=433 ms
64 bytes from 44.140.4.251: icmp_req=73 ttl=61 time=315 ms
64 bytes from 44.140.4.251: icmp_req=74 ttl=61 time=196 ms
64 bytes from 44.140.4.251: icmp_req=75 ttl=61 time=374 ms
64 bytes from 44.140.4.251: icmp_req=76 ttl=61 time=256 ms
64 bytes from 44.140.4.251: icmp_req=77 ttl=61 time=433 ms

We can also see that tun2 is now lost in OSPF

user@R0:~$ show ip ospf neighbor
Total number of full neighbors: 2
OSPF process 0 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
44.140.1.23	1	Full/ -	00:00:40	10.4.0.2	tun0	0
44.140.4.249	1	Init/ -	00:00:26	10.4.1.1	tun2	0
44.140.4.249	1	Full/ -	00:00:35	10.4.3.1	tun1	0

user@R1:~$ show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 0 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
44.140.4.1	1	Full/ -	00:00:31	10.4.3.0	tun1	0

We also tested switching one of the NPR modems off for a while and then on again to confirm that everything came back up and worked as expected after a break.

7. Conclusions and Future work

The observations in the validation section above demonstrate that the NPR link works as a narrow-band backup and that automatic fail-over via OSPF is feasible. The experiment was continued over a few days and the network seemed stable.

During the tests, the NPR modems were indoors and close to each other with dummy loads instead of antennas. It remains to learn about what distances will be possible to cover. In a full scale deployment, the NPR links should be switched on only when necessary, in order to minimize QRM disturbing others.

8. References

[1] AMPRNet Sweden home page is at www.amprnet.se

[2] Guillaume F4HDK New Packet Radio Project home page: https://hackaday.io/project/164092-npr-new-packet-radio

[3] Guillaume F4HDK NPR Protocl Specification version 2.0, September 2019

[4]Uiquiti ER-X sfp router https://dl.ubnt.com/guides/edgemax/EdgeRouter_ER-X-SFP_QSG.pdf

[5] EdgeOS User Guide https://dl.ubnt.com/guides/edgemax/EdgeOS_UG.pdf

[6] Elekitsorparts NPR-70 Modem https://elekitsorparts.com/product/npr-70-modem-by-f4hdk-new-packet-radio-over-70cm-band-amateur-radio-packet-radio

[7] RaspberryPi Foundation http://www.raspberrypi.org

[8] Verotelecom VR P25-D Power Amplifier https://rigreference.com/rigs/6382-vero-global-communication-vr-p25d