Celebrating a hundred years of Amateur Radio

Experimenting with High-Speed Wireless Networking in the 420 MHz Band

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Introduction

- desire to celebrate the centennial of ham radio

- general project requirements
  - systems integration project – little development
  - involves the outdoors and ham radio friends
  - possibly benefit public service and emergency communications
  - non-hams and young hams can relate to project
At the 2011 DCC, Charles, G4GUO and Ken, W6HHC presented their DATVexpress project. They wondered: would it be easier to build a high-speed data link with commercial off the shelf (COTS) hardware and software?

Chris, KB3CS at MARC suggested to look at Doodle Labs 420 MHz high-speed data radios.

Blog page from Steve, KB9MWR, short video from Kyle, N0KEW and documentation page from Joseph, N9ZIA.
Learning DD-WRT

● purchased
  ● Ubiquiti RouterStation Pro router boards
    ● three miniPCI card slots
  ● Wistron CM9 2.4 GHz Wi-Fi miniPCI cards
    ● Doodle Labs and Xagyl cards are drop-in replacements

● ordered
  ● Doodle Labs DL435-30 420 MHz miniPCI cards
  ● AIR802 MMCX male to N female connector pigtails
  ● later, Xagyl Communications 420 MHz XC420M cards
miniPCI 420 MHz data radios

- Doodle Labs DL435-30 and Xagyl Communications XC420M
  - software interface: appears as 802.11b/g Wi-Fi card in the 2.4GHz band
- Qualcomm Atheros AR5414A chipset at 2.4 GHz
- RF Micro Devices RF2051 VCO and mixer transverter stage to 420 MHz
- RF out about 1/2 watt (+28 dBm)
- RF bandwidth: 5 MHz centered at 422.5 MHz (ATV)
  - DL435-30 – wireless channel 1 – 2412 MHz
  - XC420M – wireless channel 2 – 2417 MHz
  - “1/4 bandwidth”
- auto fall back: 64QAM, 16QAM, QPSK, BPSK (COFDM)
miniPCI 420 MHz data radios

Doodle Labs DL435-30 with shield removed  (KB9MWR photo)
Ubiquiti RouterStation Pro

Doodle Labs DL435-30 miniPCI card in Ubiquiti RouterStation Pro
home brew quarter wave 420 MHz antenna on a large tuna fish can
Ubiquiti RouterStation Pro

- reflashed OpenWRT with DD-WRT

- exercise one: configure a RouterStation Pro router as a 2.4 GHz Wi-Fi client
  - connect to house Wi-Fi access point

- exercise two: configure second RouterStation Pro router as a 2.4 GHz Wi-Fi access point
  - laptop can connect to it
  - SSID: BOARnet – Broadband Over Amateur Radio network

- exercise three: connect client router to access point router
Configuring DD-WRT

access point Wireless – Basic Settings

setting channel width, channel and TX power to +28 dBm
Configuring DD-WRT

client Wireless – Basic Settings

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wireless Mode</td>
<td>Client</td>
</tr>
<tr>
<td>Wireless Network Mode</td>
<td>Mixed</td>
</tr>
<tr>
<td>Channel Width</td>
<td>Quarter (5 MHz)</td>
</tr>
<tr>
<td>Wireless Network Name (SSID)</td>
<td>BOARnet</td>
</tr>
<tr>
<td>TX Power</td>
<td>18 dBm</td>
</tr>
<tr>
<td>Antenna Gain</td>
<td>0 dBi</td>
</tr>
<tr>
<td>Noise Immunity Level</td>
<td>Auto</td>
</tr>
</tbody>
</table>

setting channel width and TX power to +28 dBm
### Configuring DD-WRT

#### Administration – Management

**Router Management**

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Router Username</td>
<td><em>password</em></td>
</tr>
<tr>
<td>Router Password</td>
<td><em>password</em></td>
</tr>
<tr>
<td>Re-enter to confirm</td>
<td><em>password</em></td>
</tr>
</tbody>
</table>

**Web Access**

```
Protocol: HTTP
Auto-Refresh (in seconds): 3
Enable Info Site: Enable
Info Site Password Protection: Enabled
Info Site MAC Masking: Enable
```

**Remote Access**

```
Web GUI Management: Enable
Use HTTPS: Disable
Web GUI Port: 8080  (Default: 8080, Range: 1 - 65535)
```

**Remote Web access enabled on port 8080**
network configuration

access point
192.168.2.199 (WAN)
192.168.10.1 (LAN)

netbook
192.168.2.99

client
192.168.10.2 (WWAN)
192.168.20.1 (LAN)

netbook
192.168.20.99
Access point router network configuration

- 192.168.10.1   LAN
- 192.168.2.199   WAN

- D257 Aspire one access point netbook
  - 192.168.2.99   netbook

- Web browser pages
  - 192.168.10.1  access point LAN
  - 192.168.2.199:8080  access point WAN
  - 192.168.2.99:8081  access point Yawcam
  - 192.168.2.99  access point HFS
  - 192.168.10.2:8080  client WAN
  - 192.168.10.2:8081  client Yawcam
  - 192.168.10.2  client HFS
Client router network configuration

● 192.168.20.1    LAN
● 192.168.10.2    WAN

● D255E Aspire one client netbook
  ● 192.168.20.99    netbook

● Web browser pages
  ● 192.168.20.1    client LAN
  ● 192.168.10.2:8080    client WAN
  ● 192.168.20.99:8081    client Yawcam
  ● 192.168.20.99    client HFS
  ● 192.168.2.199:8080    access point WAN
  ● 192.168.2.199:8081    access point Yawcam
  ● 192.168.2.199    access point HFS
Application software

- **Yawcam – Yet Another WebCAM**
  - has built-in video streaming Web server
  - client Web browser can select frame rate and quality
  - microscope article in *QST* March 2012

- **HFS – HTTP File Server**
  - Web server that only serves files
  - download rate in *Firefox* Downloads window
Range test – in the house

Bandwidth Monitoring - Wireless (ath0)

In 6 Mbps
Out 108 Kbps

Switch to bytes/s
Autoscale (follow)

Doodle Labs DL435-30 file download 20 feet apart
Range test – in the house

Bandwidth Monitoring - Wireless (ath0)

In 6.23 Mbps  
Out 112 Kbps

Switch to bytes/s
Autoscale (follow)

6 Mbps
4 Mbps
2 Mbps

Xagyl Communications XC420M file download 20 feet apart
Range tests – Shenandoah Valley

- acceptance criterion
  - at least one Mbit/s data rate
  - at least 10 mile distance

- Skyland Lodge patio to Massanutten Mountain – 13 miles (21 km)

- Hogback Mountain overlook to Reddish Knob – 57 miles (92 km)

- July 2005 QST: IEEE 802.11 Experiments in Virginia’s Shenandoah Valley by David Fordham, KD9LA
  - Jason, N4DSL experimenting with long range 2.4 GHz
Range tests – Skyland Lodge to Massanutten Mountain

Elevation profile

Skyland Lodge to US 211 on Massanutten Mountain

ARRL and TAPR Digital Communications Conference 20 of 40 September 21-23, 2012 - Atlanta, GA
Range tests – Skyland Lodge to Massanutten Mountain

M2 420 MHz Yagi antenna with router
Range tests – Skyland Lodge to Massanutten Mountain

station power supply

18 aH battery, 75 W power inverter, Ubiquiti 48 V POE adapter
Range tests – Skyland Lodge to Massanutten Mountain

Aleks, W3JAG and Vic, WB2U on Skyland Lodge patio
Range tests – Skyland Lodge to Massanutten Mountain

at Massanutten Mountain:

Aleks, W3JAG and Vic, WB2U on Yawcam at Skyland Lodge
2012 July 10

- Skyland Lodge patio: 3650 feet (1113 m)
- Massanutten Mountain US 211: 1500 feet (457 m)
- distance: 12.8 miles (20.6 km)
- data radio: XC420M
- antenna: M2 420-50-11 Yagi
- signal quality: 32 %
- bandwidth: 2.5 Mbit/s
- file download: 296 Kbyte/s
2012 July 29

- Skyland Lodge patio: 3650 feet (1113 m)
- Massanutten Mountain US 211: 1800 feet (549 m)
- distance: 13.2 miles (21.2 km)
- data radio: DL435-30
- antenna: M2 420-50-11 Yagi
- signal quality: 35 %
- bandwidth: 4.5 Mbit/s
- file download: 400 Kbyte/s
Range tests – Hogback Mountain to Reddish Knob

Elevation profile

Hogback Mountain overlook to Reddish Knob
Range tests – Hogback Mountain to Reddish Knob

stack Yagi antenna array with router
Range tests – Hogback Mountain to Reddish Knob

Eugene, KB3TZH on Hogback Mountain overlook (W3QX photo)
Range tests – Hogback Mountain to Reddish Knob

David, W2LNX on Reddish Knob  (KB3CS photo)
Range tests – Hogback Mountain to Reddish Knob

at Reddish Knob:

Eugene, KB3TZH on Yawcam at Hogback Mountain Overlook
● 2012 September 10

● Hogback Mountain overlook: 3383 feet (1031 m)
● Reddish Knob: 4396 feet (1339.9 m)
● distance: 56.5 miles (90.9 km)
● data radio: XC420M
● antenna: M2 420-50-11 Yagi stacked array
● signal quality: 28 %
● bandwidth: 300 to 500 Kbit/s – choppy
● file download: 50 Kbyte/s
Range tests – Hogback Mountain to Reddish Knob

needed to increase Sensitivity Range (ACK Timing)

access point bandwidth page in Reddish Knob (120 s)
Conclusions and recommendations

● both the Doodle Labs DL435-30 and Xagyl Communications XC420M data radios passed our acceptance test
  ● 10 to 20 miles appears to be a practical distance

● DL435-30 is faster but XC420M is cheaper and is available in the U. S. and Canada

● succeeded in assembling system with COTS equipment

● needs line of sight
  ● 420 MHz is more forgiving than 2.4 GHz
Continuing work

- continue our range tests
  - comparing DL435-30 and XC420M

- continue learning DD-WRT
  - what are optimum settings? for ACK timing?

- create network of three routers
  - wireless networking bridge
  - one omni-directional antenna or
  - two Yagi antennas in different directions

- internetwork with distant 2.4 GHz wireless LANs
  - HSMM-MESH™
Continuing work

- learn to stream digital video with UDP (no ACK)
  - be more DATV-like

- add VOIP and audio applications

- evaluate other COTS routers that run DD-WRT
  - Gateworks Avila GW2348-4
  - PC Engines alix2d13
  - Intel Atom motherboard with PCI to miniPCI adapter

- evaluate bi-directional linear broadband amplifiers in 420 to 432 MHz ATV sub-band
Continuing work

● **improve county public safety backup communications**

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## Optimizing Amateur Radio Resources for Major Disasters

How a single radio operator can provide emergency HF e-mail service to three hospital EOCs at once.

Victor Cid, W3CID, and Andrew Mitz, WA3LTJ

Hams have a long history of technical development for disaster preparedness. The National Library of Medicine (NLM), part of the National Institutes of Health (NIH), has tapped a technically savvy group of hams in the Washington, DC area to develop last resort e-mail communications for three area hospitals. This ambitious project has created a new approach to providing e-mail service to large groups of users during major disasters.

**BHEPP — a Unique Partnership**

The project began in Bethesda, Maryland where you will find three very different major hospitals across the street from one another. The Bethesda Hospitals’ Emergency Preparedness Partnership (BHEPP) was created to leverage clinical resources of the Clinical Center (NIHCC), a world-famous research hospital, and the Suburban-Johns Hopkins Hospital, an acute care hospital with a regional trauma center. BHEPP is the first military-civilian-federal partnership in the US. The Partnership received funding to conduct a series of research, development and infrastructure projects. The NLM, the world’s largest medical library and a leading medical-informatics research facility, joined the partnership in 2008 and leads the implementation of the projects. After recruiting a team of ham and MARS radio experts, the project leaders set out to develop the BHEPP MARS/Winlink2000 Emergency Radio e-mail System (BMERS).

**Could It Be Done?**

operator with a single Winlink 2000 station provide emergency e-mail service to not just a fully staffed emergency operations center (EOC), but to three large EOCs at once? After many months of research and development, these hams found the answer and have a prototype system to prove it.

**EmComm and HICS**

As ARRL Emergency Preparedness Manager Mike Corey, W5MPC, will tell you, if you are going to provide emergency communications (EmComm) for an agency, you had better understand how that agency operates. Health facilities such as the BHEPP hospitals use the Hospital Incident Command System (HICS) to manage emergencies. This system provides an organizational and
Acknowledgment

- members of Montgomery Amateur Radio Club
  - Aleks, W3JAG
  - Chris, KB3CS
  - Eugene, KB3TZH
  - Vic, WB2U
  - William, W3QX

- Shenandoah Valley
  - Jason, N4DSL

- many others...
Acknowledgment

I received this book when I was a child... Thank you!
Questions

demonstration in the play room