Creating A City-Wide Portable Residential Digital Packet Repeater Backbone

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INTRODUCTION

Packet or other digital ham radio communications have a far higher throughput of data than voice communications. (http://qsl.net/kx4z/ThroughPutWeb.pdf) Packet (AX.25) is an older technology whose popularity faded after the invention of cell phone text messages. It is currently experiencing a resurgence for emergency communications in situations where cell phones may be unusable. However, while voice repeaters are widespread, packet digital repeaters may be more scarce. In my location, we were dependent on ***one*** local SEDAN-associated digital repeater, which performed well, but had no backup. (http://www.fla-sedan.com/sedanmaps.html)

Ideal emergency assets would have two essential qualities:

1) they have immediate backup electrical power (and can be refilled if needed);
2) they are easily accessible even during disasters, for repairs.

Often (not always) high-tower or high-building based digital repeaters have great range, but don't have electrical backup and require intricate permission or even professional tower crews to reach for repair.

PROCESS

As a result, in my city I set out to create a digital backbone based on homeowner-managed residential digital repeaters using tree limb based antennas. At this point we have five such systems in place, four of which are very portable, and our total linear coverage exceeds 20 miles, covers over 50% of the population of our city (defined as to a tree-limb based home antenna) and covers roughly 200 square miles. This article is to explain what worked for us. Our system is still growing, and has provided a wonderful mechanism to raise the technical prowess of local amateurs; new Technician licensees have enthusiastically joined the effort and it has been a major focal point for our local ARES group.

Terminal Node Controller: This system could be created with commercial Kantronics TNC's and would certainly perform well. We opted instead for a Raspberry-Pi (version 3) based solution, based on the success of the TAPRN group. (http://tarpn.net/t/packet_radio_networking.html) The very popular Tigertronics Signalink is not optimally supported by current Raspbian software, particularly the semi-graphical mixer control, `alsamixer`. We developed a very inexpensive (but homebrew) TNC based on a $5 Adafruit USB-audio adapter and a small transistor/relay push-to-talk circuit. (http://www.qsl.net/kx4z/TNCConstruction.pdf) We found that using a relay to control the PTT resulted in much less RFI difficulty than attempting open-collector output control, but we did not find transformer audio isolation necessary in any case so far.

Software: We have developed a standardized Raspbian based software which is easily copied to a new chip using the included software and a cheap USB card reader/writer. We are using John Wiseman's excellent LINBPQ software (https://dl.dropboxusercontent.com/u/31910649/LinBPQ_RMSGateway.html) , as well as DIREWOLF. (https://github.com/wb2osz/direwolf/releases) We compiled a recent version of FLDIGI including KISS tcp/ip access, and provided CHROMIUM web browser, SSH, and TightVNC to allow distant access if necessary (which of course might not work in a disaster). (http://www.qsl.net/kx4z/AdvancedRaspberryOptions.pdf)

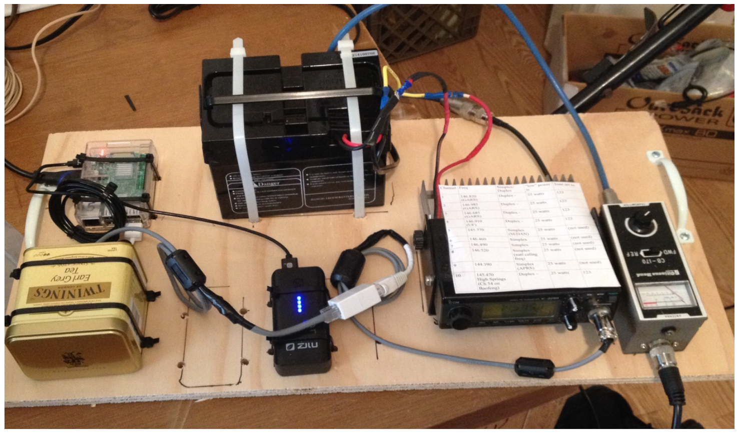
Radios: We purchased used 2-meter transceivers on Ebay, and became familiar with how to replace defective power amplifier modules. We typically purchase ICOM-28, ICOM-229, FT-1900, and similar 25-50 watt radios and run them at 25 watts output.

Battery Backup: The 2-meter transceivers spend relatively little time transmitting. They are powered by 7.5 Ahr 12 volt gel cells, which are charged with a 2-Amp Stanley battery maintainer. A 2-A charger can theoretically provide 24 watts. (https://www.walmart.com/ip/Stanley-2-amp-Battery-Charger/14560006)

Raspberry Backup: Linux systems should not be allowed to have power failures. Therefore we provided 4400 mAHr cell phone battery backup, with standard 2 Amp cell phone chargers powering the backup battery. We found a brand of backup battery that could both be charged and provide power simultaneously.
(https://www.amazon.com/gp/product/B00MWV1TJ6/ref=oh_aui_detailpage_o09_s00?ie=UTF8&psc=1)

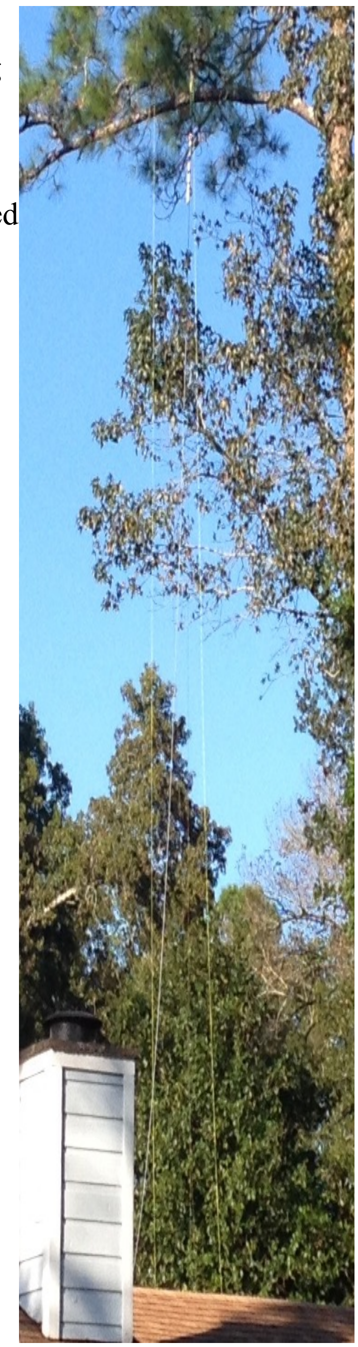
Output indication: For emergency usage, it is useful to know for certain that the transceiver is providing output. At the moment, we are using inexpensive Ebay-accquired HF SWR meters to give relative output. The SWR reading is inaccurate. (http://www.kb6nu.com/no-vhf-swr-meter-no-problem/) We add a 230-volt gas discharge surge arrestor to give at least a bit of EMP and electrostatic discharge hardening. This is soldered between the center conductor and shield of the antenna SO-239 on the SWR meter. (http://www.digikey.com/product-detail/en/epcos-tdk/A81-A230X/495-1471-ND/652695)

Mounting: We took 2 foot x 2 foot 1/2" plywood from Home Depot, sawed them to 1 foot by 2 foot, installed pickup handles at left and right side, and stablized equipment by drilling holes and securing with zip ties. The heavy 12 volt batteries were additionally glued with epoxy. Small #4 screws were placed to help hold the SWR meters



Antennas: A previous educational project had involved many members of our ARES group building simple Slim Jim antennas based on 1x2 pressure treated wood,, with 14-gauge house wiring for the element and matching system. (http://qsl.net/kx4z/TwoMeterHomeMadeSlimJim.pdf) Using slingshots (and in one case, a novel usage of a fishing pole!) we we routinely positioned ropes at 50+ feet in various trees, and used RG-8X (generally 100-feet) to connect to the antenna.

Example of 50+ foot high antenna, with ropes and extra safety ropes present.



Station locations were chosen based on a combination of homeowner interest, avilable funds, and the ground elevation of the location, as well as tree availability. We have some hilly features to the terrain of portions of our city, with ridges and valleys separated by > 100 feet. Some of our homeowners are at 160+ ft MSL elevation, while our WINLINK VhF/HF gateway station was unfortunately only at 100 ft MSL. The chosen stations allowed interstation distances up to 6 miles with acceptable signals and connection rates.

ITEM	TYP COST
2-meter used radio	$90 typically
Raspberry PI w/case	$45
8 Gbyte Kingston SD memory	$5

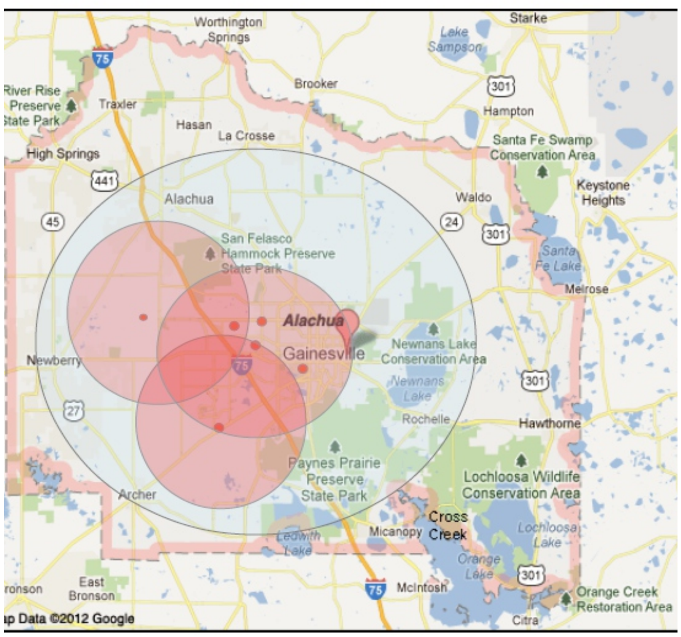
Homebrew TNC	$15
7.5 Ahr 12 volt battery	$25
Stanley battery charger	$20
Cell phone back up battery	$14
Cell phone heavy duty charger	$10
Used HF SWR meter	$15
230V gas discharge tube	$3
100 foot RG8X	$45
Homebrew Slim Jim antenna	$5
Rope to hold antenna	$8
Various cabling / connectors	$20
Plywood & pull handles	$7
ESTIMATED TOTAL	$337

Educational Development: The antenna project's success led to consideration of this project. As expertise with the linbpq software grew, the chances of success improved. The first station installed was fairly disorganized, and we later discovered the transceiver had virtually zero output. Flexibility and humor played a large role in keeping the project alive. It helped that among our group were people with Information Technology and linux experience. Once RFI issues were somewhat under control (Signalinks were great on that score) the station development proceeded more rapidly. (We still use cron tasks to reboot the raspberries every 6 hours in case RFI freezes a port.)

We held training sessions to explain packet communications; to demonstrate digipeater versus CONNECT situation; to demonstrate WINLINK; to demonstrate telnet. We taught new "sysops" how to use VNC and PuTTY. Antenna parties developed to put in new antennas similar in concept to old-fashioned "barn raising" parties. In once instance we even installed a very complicated multiple band vertical antenna! We are in the process of a very extended session to build homebrew TNCs for users --- the group's level of circuit homebrew capabilities was in need of elevation.

OUTCOMES

To date, we do not have the same level of coverage that one highly placed SEDAN node has (blue tinted circle in the Figure) but we have an impressive coverage in the middle and western portion of Gainesville, Florida. Our system spans more than 20 linear miles and covers hundreds of square miles, and more than 50% of the population, if judged by the ability to connect using a tree-level elevated antenna. Our ARES group has never been so energized. Friendships have been forged from the shared experiences. Antenna, equipment, computer, networking and general ham radio knowledge have blossomed in our group. We are not yet at the position where we have en mass understanding of usage of the equipment, but our present course will reach that level within a couple more months. At that point, the users' and sysops' level of understanding will reach that point that not only can they reconfigure to a new frequency, they could realistically be given directions to drive each system to a different location, put up a new antenna, and create an adhoc network to provide emergency digital access out of a disaster area back to "civilization." The rural areas surrounding our town contain many elevated fire towers at roughly 150 feet elevation, and installing systems with antennas at those heights would give a radio horizon distance of roughly 15 miles; with four such portable stations, one could span 45 miles of linear distance.



Map of Alachua County with superimposed estimates of coverage (to a tree-elevated omnidirectional antenna) by: SEDAN high-elevation node (pale blue circle); residential LINBPQ nodes (pale red circles) -- red dots mark approximate locations of various digital repeaters.