

## **Developing Broadband-Hamnet Statewide**

Frank M. Howell, PhD K4FMH  
Assistant Director, Delta Division, ARRL  
Vice Director, Mississippi, SERA  
k4fmh@arrl.net

Rez Johnson K1REZ  
District Emergency Coordinator, District 6, Mississippi  
kirez@arrl.net

### **1. Broadband-Hamnet in amateur radio**

One of the recent developments in the microwave frequency bands allocated to amateur radio is broadband-hamnet (BBHN) networking. BBHN was the focus of the ARRL QST July 2013 cover story. It has also received prestigious awards for innovation from the International Association of Emergency Managers. Quoting the main website (<http://broadband-hamnet.org>):

“Broadband-Hamnet™ (formerly called HSMM-Mesh™) is a high speed, self discovering, self configuring, fault tolerant, wireless computer network that can run for days from a fully charged car battery, or indefinitely with the addition of a modest solar array or other supplemental power source. The focus is on emergency communications.”

Three key phrases---self discovering, self configuring and fault tolerant---indicate that individual “mesh” nodes will find other nodes within range, automatically connect to them, and will handle errors in reception by retrying until each packet is confirmed---make this technology highly “plug and play” once each node is initially programmed with the correct parameters.

Think of it as commodity WiFi but on the amateur radio frequency segments in the 13cm band. It emerged when some enterprising hams wrote computer code to reprogram the firmware of the venerable Linksys WRT54G router models that had enough memory on board to execute the “mesh” code upon boot-up. Thus, most any application that will operate over plain commodity WiFi networks will also work on Broadband-Hamnet. This includes voice-over-IP telephone, e-mail, instant messaging, video streams, web servers, and so forth. These “mesh” networks have been used for Field Day or other contests to simplify multiple logging on a local-area network (LAN). All data are digital and communicated much as amateur radio repeaters operate, from node-to-node. In addition, a BBHN node can be connected (or bridged) to the commodity Internet or to another more distant “mesh” network.

Certain old Linksys WRT54G routers, selected Ubiquity wifi access points, and even the inexpensive Raspberry Pi computer can be configured as BBHN nodes. Others may be on the horizon as development in the 3.4 Ghz and 5.4 Ghz frequency ranges is coming to fruition. More details are available at the main website for BBHN. We highly encourage readers to read through this website and to study the portions recommended by the maintainers of that informative site.

In this article, we provide some recommendations for planning, implementing, and growing a coordinated BBHN system in a state. In the following section, we give the rationale for BBHN systems needing some type of collective coordination, illustrate a local community's pioneering work in Mississippi, and outline a strategy for connecting communities statewide.

## 2. Some principles of statewide organization for coordinated communication systems

Modern repeater systems need coordination for several reasons, nontheleast of which is that they are *group activities*. Some 30 years ago, the first author was involved in the construction of several computer networks used for communication among professionals (Howell 1985). This was prior to the Internet becoming widespread or even BITNET (an email and file-transfer precursor) being widely used. In that work (see also Howell and Garson 1985), Howell argued that that is an additional element to the “technical organization” of computer (technology) mediated communication which is how individuals and groups use the information, exchange it, and act on the basis of it. He called this the “social organization” element. This distinction can be applied to amateur radio repeaters as well as BBHN systems. It is shown in Figure 1.

### Figure 1. Conceptual Model of the Organization of Amateur Repeaters and BBHN Systems

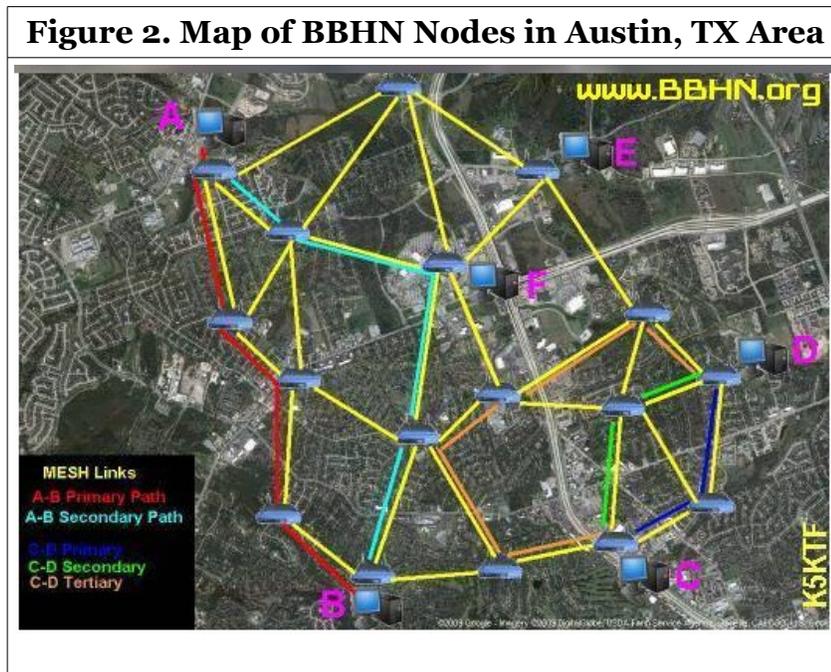
<b>Technical Organization</b>	Hardware and software potential existing in the communication system and operator's immediate “network” environment
<b>Social Organization</b>	Patterns of how information/data is processed by radio and network hardware/software and how human operators deal with this information and the human-to-human interface

What does this mean in practical terms for repeaters and “mesh” systems?

The concept of a network in amateur radio has two connotations. One is a socially constructed idea of a defined group of amateurs holding “directed” conversations at a given time on a given frequency. The “directions” for the network (or even the more casual round-table) represent non-technological patterns of organization, such as who can transmit and when and with what information. A second is how hardware is connected through explicit configurations to communicate from one transmitter/receiver pair to another. For instance, repeater transmission frequencies and reception frequencies are explicitly identified along with any required underlying tones in repeater coordination listings so that users know how to set their own transceivers for effective communication. The latter is basic amateur radio knowledge but the former is usually taken for granted in a larger sense. Don't believe this? Why do so many ask for help in programming their DSTAR rigs? Or their inexpensive HTs? It's because the “technical” organization of both Icom DSTAR rigs as well as the inexpensive handy talkies produced in China so not conform to the simpler formats by, say, Yaesu or Kenwood that have become part of the “social” organization of repeater use.

This same general principle applies to Broadband-Hamnet Networks. We've had decades to work out the “organization” protocols for repeater use. But other than small localities with

several BBHN nodes in full-time service (see <http://broadband-hamnet.org>), amateur radio has yet to deploy wide-area “mesh” systems, say on the order of a state, unlike repeater systems. One of the largest such systems can be seen in Figure 3 which is taken (by permission) from the BBHN website, courtesy of Jim Kinter K5FF (personal communication).



One can see from this map, the nodes were strategically placed to achieve line-of-sight (LOS) to at least two or more other nodes. This will allow the “self-healing” ability of a node to remain connected if one of it's links goes down. The outline to K5KTF's graphic shows the technical organization of information flow in terms of primary, secondary and tertiary network links. This is just an example of one locality's implementation. It depends upon the topography of both the land and structures upon which permanent nodes can be placed.

**The key questions facing the amateur community regarding BBHN is how to organize both the technical and social organization of the technology so as to make it effective for use in both emergency communications as well as for other means.** We focus on one approach currently being followed in the Mississippi section of SERA. This brief discussion uses one local community---Scott County, MS---and it's implementation for that community and then outline how it can be expanded statewide across Mississippi over the coming decade. We believe that it may take up to ten years for this adoption curve to reach its full potential.

### 3. Local implementation: Scott County MS

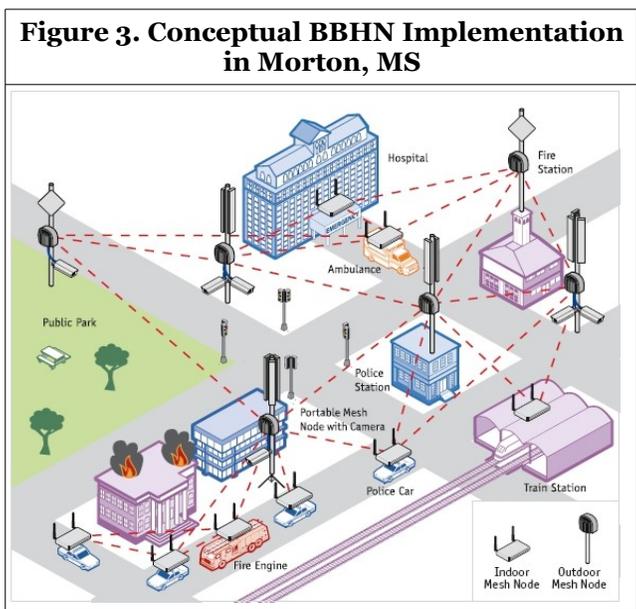
The Scott County Amateur Radio Club (<http://www.scottcountyar.org>) is a relatively new group located in the small town of Morton, MS. Morton is situated along I-20 just east of the capital of Jackson and west of it's county seat of Forest, MS. The club draws members from surrounding areas at its monthly meetings. At the encouragement of the first author who gave a talk on BBHN as an outreach of the Delta Division of the ARRL, the second author discussed this with Club members who decided to construct the first “mesh” network in Mississippi. On

behalf of the League Delta Division, Howell contributed some Linksys routers, omnidirectional antennas, and MFJ donated several of their 2.4 Ghz Yagi (MFJ-1800) antennas to the Club's effort.

To distinguish this from a “garage” based network that a single ham experiments with, the first author arbitrarily defined an operational BBHN network as three or more nodes assisting a served agency. One may disagree with this definition but until a more effective one is put forth, that is what we are using in Mississippi.

On Saturday, May 3rd, the Scott County ARES Team and the Scott County Amateur Radio Club were the first in the state of Mississippi to transmit live video via Amateur Radio Broadband. Live color video of the start and finish line of the Morton Day in the Park Bike Race was transmitted over a quarter of a mile away and projected onto a screen at the club's demonstration booth. Festival-goers enjoyed being able to view the race from the convenience of the Club's Command Center (a tent!). City officials, including the Mayor, were given brief overviews of the technology as well as how their police and fire personnel were assisted through this amateur radio technology.

To illustrate the approach in Scott County, Figure 3 shows where served agency nodes are being placed as well as portable nodes involving licensed amateurs working with local officials. This illustrates the social organization of what uses are being planned in this community.



The Scott County Amateur Radio Club plans to provide this service to other bike and foot races around the state as a means of keeping our video over amateur radio skills sharp for emergency event purposes. As an EmComm focused club, the primary goal is to be trained, ready, and capable of deploying to emergency and disaster areas for transmitting live video of disaster scenes and staging areas back to viewing screens at Incident Command Posts and Emergency Operations Centers. If a picture is worth a thousand words, then live video is worth ten thousand words, especially during an emergency. Additional development for web

servers illustrating the locations of nodes, APRS trackers along with VOIP service, e-mail, and instant messaging to served agencies and back to the MS EMA EOC is aggressively underway. Solar power nodes have developed with the assistance of Steve Powell KF5QXU as shown in Figure 4.

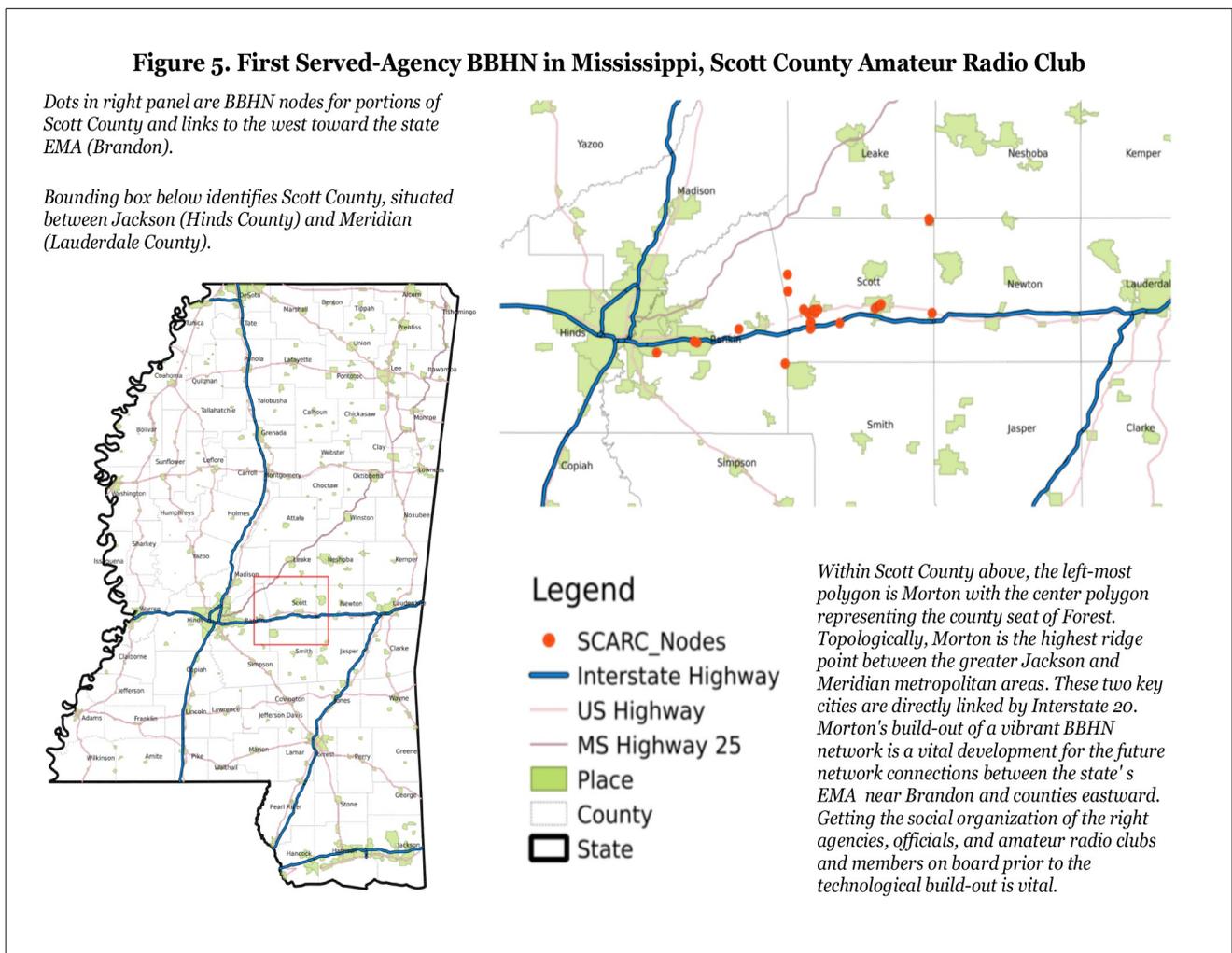
**Figure 4. Solar-Powered Temporary BBHN Node Deployed in Public Race Support**



The focus is on providing emergency communications to our served agencies and team

members by linking their computers via amateur radio during emergencies or disasters which knock out normal communications. Every computer connected by amateur radio to our BBHN is able to do most everything a computer in a standard office network can do, except we do it over a very large area: send and receive network wide email, host chat rooms, instant messaging, view and edit network wide web-pages, send forms, documents, photographs and video, share files and peripheral devices, and talk on the phone with each other using Voice Over Internet Protocol (VOIP).

As the ARRL ARES District Six Emergency Coordinator for East Central Mississippi (District 6), Johnson K1REZ plans to establish nodes in the county seat of Forest, MS. The Scott County ARES Team has also been establishing linking nodes in other counties in order to create a direct network link from the Scott County Emergency Operations Center (EOC) to the Mississippi Emergency Management Agency's State Emergency Operations Center (MEMA's EOC) located to the west in Pearl, MS. This planning is illustrated in Figure 5.



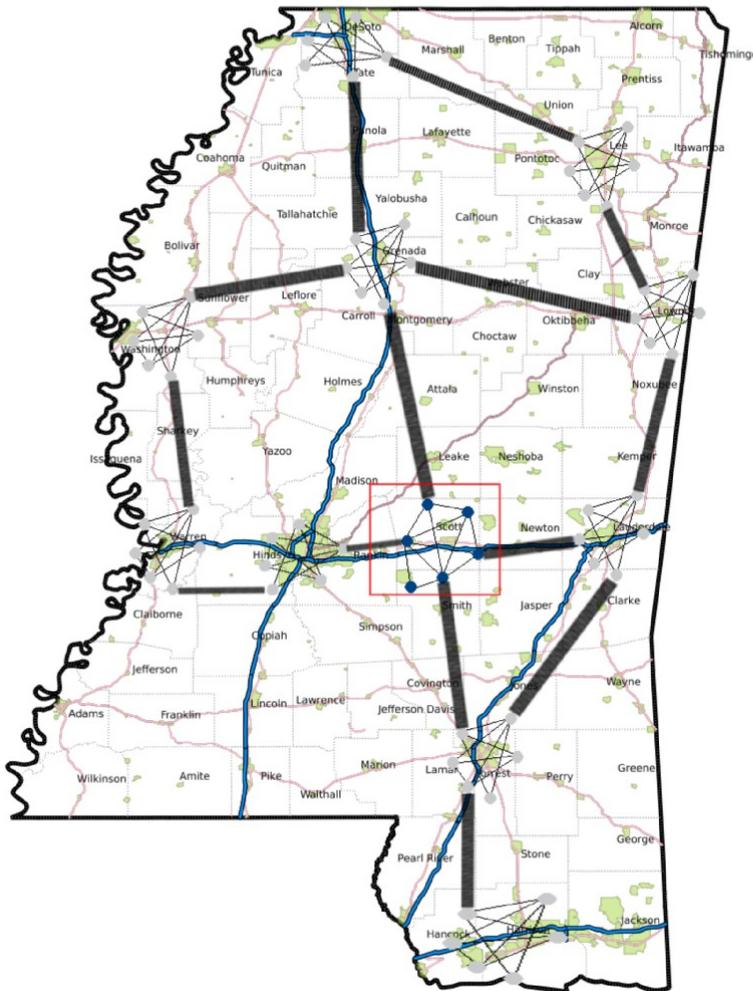
#### 4. Statewide Scaling of BBHNs

From our experiences thus far, it seems important to educate both fellow hams as well as those in the emergency response and policy-making communities about BBHN. We created a

Yahoo Group called MS Broadband-HamNet (technically, MS-HSMM-MESH on Yahoo Groups) so that others could learn about our initial steps toward building BBHN in the state. Other cities have done this with great success too.

Figure 6 is a planning map showing these ideas to build local “mesh” communities first but build them out using commodity Internet connectivity.

**Figure 6. Build-Locally But Build-Out Concept in Mississippi**



*The original BBHN system in Scott County is shown in the square bounding box with dark circles to symbolize local sets of nodes. Other lighter circles are planned BBHN communities reflecting club interest and initial node development.*

*The dark lines connecting these localized BBHN networks are virtual tunnels using commodity Internet connectivity. Perhaps one day, node density will be such that few if any of these Internet bridges will be needed. But for the short-run, they will serve a grand purpose for making the BBHN technology useful, innovative, and exciting to use!*

*These connections would link Scott County, Meridian, Jackson, Vicksburg, Hattiesburg, Biloxi-Gulfport, Greenville-Cleveland, Grenada, Columbus, Tupelo, and Southaven. All are key population centers in the state of Mississippi.*

*Many emergency personnel are dubious as to the reliability of the Internet in an event. We do not disagree. However, there are always “margins” to the Internet outage where connectivity still exists. We believe that for almost any critical event in Mississippi, the ability to connect to the “edge” of an existing BBHN and yield Internet connectivity to all nodes therein will prove to be a vital positive impact of this conceptual design.*

*In network terminology, these links represent a network backbone of connectivity amongst BBHN communities. Where a repeater Intertie exists, there are already towers with antennas in place. Adding BBHN nodes at each backbone node could add quite a bit of additional network connectivity, especially as mobile BBHN nodes become more commonplace. Experimentation here is the cardinal activity!*

There are a few ideas that should be considered in this development strategy:

- a. Get your nodes working reliably before doing a show-and-tell to others.
- b. Recall the “killer app” for convincing skeptics that personal computers were viable was the spreadsheet. For BBHN, it seems that VOIP telephony and live video might be those killer applications where “seeing is believing”. Deliver up-front to others unfamiliar with BBHN.
- c. Develop local communities of BBHN nodes reflecting a specific club or ARES group's membership. This yields a critical density of nodes where most local area traffic will

occur.

d. The line-of-sight in the local topography will dictate the node topology. That is, unlike the need for a single tall site for a voice repeater to serve a community, BBHN does not necessarily require it. On the other hand, peaks and valleys can easily produce RF “dead zones” in BBHN systems too. It just varies! Use Jim Kinter K5KTF’s “Path Profiling in Google Earth” on the BBHN website (<http://www.broadband-hamnet.org/documentation/140-np2x-path-profiling-in-google-earth.html>) to plan where and how many nodes are likely needed.

e. Using commodity Internet connections among these local communities so that the BBHN village can communicate with other club members. This will involve “virtual tunneling” connectivity (see <http://www.broadband-hamnet.org/documentation/120-creating-a-tunnel-network.html> as a step-by-step guide).

f. Develop a “telephone directory” system for VOIP calls within and between local BBHN communities. Contacting a ham in another community recalls the older days of POTS “long distance” service wherein a human operator had to handle the patch cables. If a state uses a build-out conceptualization, the local systems can be uniquely identified. Planning together on this underscores the importance of the “social organization” involved in what is technology for group activity.

g. These systems are fairly inexpensive as amateur radio equipment goes. Take a careful look at what other “mesh” enthusiasts are doing with throw-away routers, antennas, telephone systems, cameras, and so forth. As the group in Austin, TX has shown, these routers operating “barefoot” can reliably communicate ten miles or more on a regular basis if proper planning is used.

## 5. Closing thoughts

Amateur radio is making great headway in the microwave frequency band allocations. Certainly the Broadband-Hamnet innovation is one of the brightest of these developments. If we can plan together, these networks can be as easy to use as commercial cellular smartphones. Just flashing a few Linksys routers into service at a park on a Saturday can get the ball rolling. But it will likely stop there without planning. Hams are not always the most effective in getting clubs to talk to one another about collective action. This is an opportunity to put that to bed.

We hope that these optimistic plans come to fruition in Mississippi. A small, new amateur radio club in a highly rural state is leading the way here. We know that others can improve on these modest beginnings. In a state devastated through hurricanes and tornadoes, Mississippi amateurs know from first-hand experience that these communications systems will play a critical role in saving human life and property: IF we can work together to build them.

## References:

Howell, Frank M. 1985. "SocNet: An International Professional Computer Network for Sociologists," in Thomas H. Moberg (ed.), *Databases in the Humanities and Social Sciences*. Osprey, Florida: Paradigm Press.