BROADBAND HAMNET MICROWAVE COMMUNICATION NETWORK

https://sites.google.com/a/temple.edu/broadband-mcomm/

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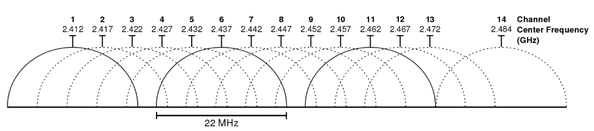
Abstract

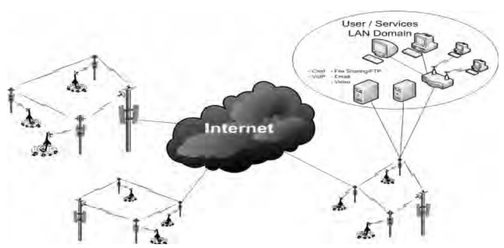
- Establish a microwave Ad-Hoc communication link between Temple University and Montgomery County Emergency Center on Amateur Radio Frequencies.
- System is setup for when traditional communication networks go down. It supplements traditional internet communication and can act as a replacement when in a emergency situation.
- Achieved with inexpensive computing devices, highly directive Yagi antennas, and repurposed routers.
- Maximum theoretical communication range is ~100 km for 720p or 75 km for 1080p video streaming.
- Develop a front-end interface that is customizable and touch friendly for quick on the go communication. Underlying protocol will be compatible for Ad-Hoc networking.

Background

- Current Amateur Radio communication is traditionally limited to text and voice (low bandwidth).
- Traditional 2.4 GHz WiFi is separated into 14 channels. Amateur Radio is on channels -1 and -2 (2.4 GHz to 2.417 GHz).



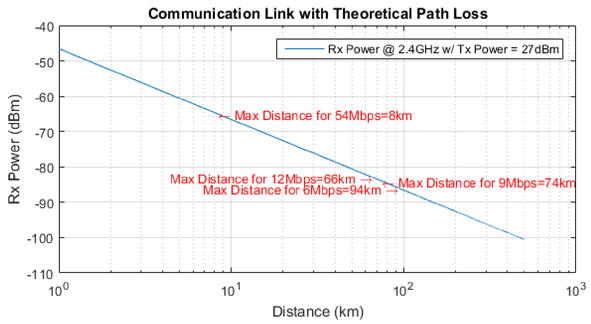
- Ad-Hoc networks work by using node access points which can dynamically structure the network.



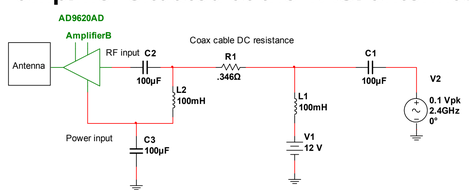
Hardware Implementation

- Use consumer grade off the shelf (COTS) hardware to keep costs down and ensure easy repairability and upgradability.
- Create a high performing Ad-Hoc node at Temple using the following:
  - WRT54G Router, Yagi Antenna, 2.4 GHz Amplifier, RaspberryPi 2 (Rpi 2)
- WRT54G Rx (receiving) sensitivity is 5 pW.
  - Reliable communication link up to 66 km @ ~12 Mbps.
- Total hardware cost: $35 (Rpi2) + $20 (WRT) + $90 (AMP), + $20 (YAGI) = $165
- Conventional Amateur Radio transceivers can run $1000+

- Measured max output power over a 20 MHz spectrum from Linksys WRT54G is 32 mW. The power is too small to Tx (transmit) directly so we increase power using a 2.4 GHz 4 W amplifier.

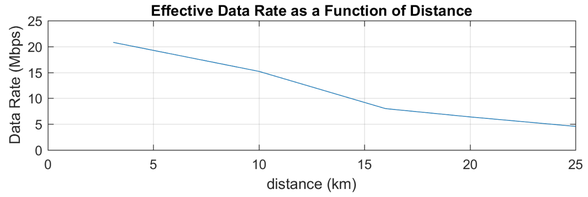


- At Temple University we have the challenge of linking our YAGI antenna located on the ENGR roof to our Amateur Radio station (K3TU) located on 7th floor.
  - Need to run DC power (12W) alongside our radio frequency signal to power the amplifier situated at the YAGI antenna.



Hardware Results

- At 25 km the path loss is 102dB. Our Tx power after line attenuation and amplification is 500mW. Rx power is 35pW.
- Actual results slower theoretical due to overhead from TCP and Carrier Sense Multiple Access (CSMA).
- Reference for Standard Video Bitrates:
  - For 720p H.264/ACC-LC = 5 Mbps
  - For 1080p H.264/ACC-LC = 8 Mbps



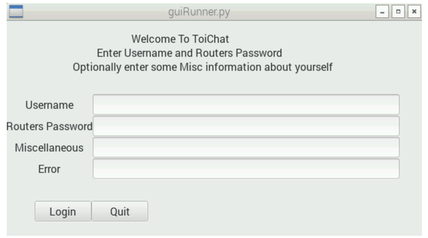
Software Results

- Multi-threaded back-end application maintains state of TOIChat network and allows for dynamic add/removal of nodes.
  - Implements TCP as transport layer communication protocol.
  - Created custom Remote Machine Discovery Protocol (RMDP) for active discovery of nodes in BBHM network.
  - Upon node discovery, the current state of TOIChat network is delivered to the new node by Optimized Linked State Routing (OSLR) procedure.
- Functional front-end allows for text messaging application via the command line.

```
toiChatShell >> startserver
Do you want start your server on a non-standard port? (yes|no):
 >>  no

toiChatShell >> forceupdatedns
Do you want to search for server on a non-standard port? (yes|no):
 >>  no
Connection to a toiChatNetwork successful.

toiChatShell >> printdns
{'KC3GIG': {'clientId': '10.119.197.28',
            'dateAdded': '20160415 - 22:32:47',
            'description': '',
            'lastPingVal': 4.527886708577474},
 'kc3gif': {'clientId': '10.247.16.45',
            'dateAdded': '20160415 - 20:28:21',
            'description': '',
            'lastPingVal': 0.5609989166259766}}

You have a new message from : KC3GIG. Open a chat window to talk back.
 >> startchat
Available users to Chat:
['KC3GIG']
Who do you want to talk to?
 >> KC3GIG
```

Software Results (continued)

- To assist the Amateur Radio community who may not know Unix environment, we will develop a user friendly Graphical User Interface (GUI) compatible with a touch screen interface.



- GUI interface is fully compatible with users who prefer command line interface.
- All software is available for public distributed via GitHub. The site includes setup instructions and installer.

Summary

- Existing Amateur Radio networks are limited to direct line of site communications.
- We show it is possible to construct a high bandwidth Ad-Hoc mesh network specifically here at Temple University.
- Using COTS hardware, we developed a mesh optimized back-end application that will supplement the capabilities of Broadband-Hamnet.
- Future work entails enabling video streaming and error-correction encoding.
- For further development we will look into ARDEN (Amateur Radio Data Emergency Network) which uses higher powered Ubiquiti Routers.

Acknowledgements

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- Also special thanks to the K3TU Amateur Radio station and the System Chip Design Laboratory.