

# Mesh Networking: Building Infrastructure Support Services

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# Disclaimer

- I, George J. Silowash, am here today in my private capacity and not my official capacity. My statements express my personal views, observations, and not those of my employer.
- This presentation contains recommendations. The software and/or hardware presented is believed to be current as of November 2014. The presenter cannot be held liable for the performance of any product, service, or configuration mentioned in this presentation.
- You are encouraged to do research before implementing any solution.
- Your mileage may vary. Void where prohibited. 😊

# George J. Silowash, KC3AAD

- Father of two
- Master Of Science in Information Assurance / Security
  - Certified Information Systems Security Professional (CISSP) – Information Systems Security Management Professional (ISSMP)
  - My security thinking gets in the way of some things, bare with me.
  - GIAC Certified Forensic Examiner (GCFE) – Think of CSI, but better ☑
- Information Systems Consultant
- Adjunct Professor at Norwich University and Harrisburg University
- Ham radio enthusiast
- Big fan of open source solutions: If I can find a way to make it free or as cheap as possible, I will do it – This seems to fit most ham radio junkies.
- **I am not a network engineer, nor do I play one on TV. I try things, break things, and do my best to understand the technology**



# Jay Schall, KB<sub>3</sub>NSJ

- Blames broken things on George 😊
- WEARS President
- Helps George spend money on toys



# What is WEARS?

- Westmoreland Emergency Amateur Radio Service
- Part of Marguerite Volunteer Fire Department (Station 33)
- We are Command Post 600 (CP600)
- Provide Emergency Communications for Township / public service events



# Agenda

- Building a Mesh Node
- CP600 Infrastructure
- Westmoreland County Airshow 2014 – Lessons from the Battlefield
- Future Work
- Show & Tell , Demos
- CP600 Tour

# Building a Mesh Node

# What is a Mesh Node?

- Broadband-Hamnet, formerly HSMM-Mesh
- “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.”[1]



# What Hardware Can Be Used?

- Linksys WRT54G Series Routers Version 4.0 or lower
  - 5.0 or higher is not compatible
  - WRT54G, WRT54GL, WRT54GS
  - Read this document:
    - [http://www.broadband-hamnet.org/images/hsmm\\_docs/WRT54Shop.pdf](http://www.broadband-hamnet.org/images/hsmm_docs/WRT54Shop.pdf)
  - Great for localized networking and testing
- Ubiquity
  - Rocket M2, Bullet M2 HP, AirGrid M2 HP, NanoStation Loco M2 (NSL-M2), NanoStation M2 (NS-M2)
  - <http://www.broadband-hamnet.org/section-blog/37-hardware-faqs/101-supported-hardware.html>

# Build Essentials

- Decide if you are going to use it outdoors, indoors, or both.
  - Outdoors: Need weather resistant case
    - Home Depot has a nice selection in electrical department
- Decide how you will power the equipment
  - Battery / Solar
  - Nuclear (aka the power grid)
- Decide what you want your node to do
  - This drives what other stuff you may want to place with the node





**KC3AAD-103**  
**10.172.89.97 (98-110)**  
**255.255.255.240**  
**WIFI: 10.170.197.150**





Wireless-G 24GHz  
Broadband Router  
**LINKSYS**

BULLET  
BY

10/100  
10/100  
10/100





BLAZET IT

LINKSYS  
Wireless-N 2.4GHz  
Broadband Router

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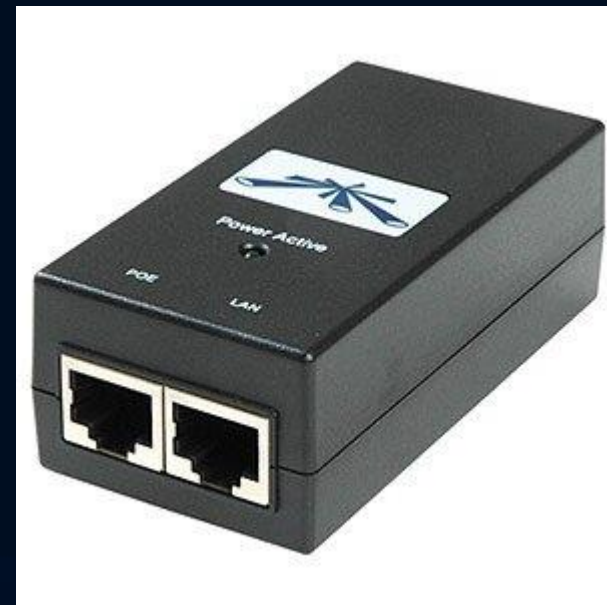
Cable





# Things You Should Have on Hand

- Power Injectors
- Several types – Very useful





# Things You Should Have on Hand (cont.)

- 12 Volt to 5 Volt Transformers (Great for Raspberry Pi Power)



Images from <http://www.amazon.com>

# Things You Should Have on Hand (cont.)

- 2.1mm x 5.5mm Male & Female power jacks (CCTV power)
- Assortment of 12volt and 5 volt power adapters with various ampere outputs
- USB Cables – Assortment ( Micro, Regular, Mini, Male/Female extenders)
- Network Cables
- Fuses, switches, lights, PCB etching materials
- Patience and willingness to learn. Remember, I break things. 😊



Images from <http://www.amazon.com>



# Building a Node- Lessons Learned

- Watch your voltage and polarity
  - I fried a 12v to 5v transformer
- Silicone is your friend when weather proofing
  - Minimize component exposure and water entry points
  - Always think about how you will keep water out
- Keep in mind where you might place a node
  - Remote power on/off
- Batteries are heavy
- PoE Injectors are awesome!

# CP600 Infrastructure



# CP600 Infrastructure Services

- Web Server
- Voice over Internet Protocol (VoIP)
- Chat
- FTP
- Web Cams
- General WiFi



# Current “State of the Network”

# What's Under the Hood?: Hardware

- Intel Atom Dual-Core D2500 1.86GHz processor
  - 4GB RAM
  - 120GB SSD Hard Drive
- Grandstream Phones (2 Line Phones)
- Various IP Camera
- Cisco Managed Switch
- TP-Link Dual WAN Router
- Rebadged Linksys Routers
- Ubiquity Bullets M2 HP
- TP-Link Antennas (Directional & Omni)
- Ubiquity AirGrid 2.4GHz & 5GHz (for Internet "pilfering")

# What's Under the Hood: Software

- PBX in a Flash (VoIP): <http://pbxinaflash.net/>
- CentOS
  - Rock Solid Linux Distribution
  - Built for Enterprise use
- Apache Web Server
- Filezilla Server (FTP)
  - Runs on Windows Laptop





# How to Build It

- Some Linux knowledge is highly recommended
  - Google is your friend
  - Webmin (GUI) helps for most administrative tasks
- Recommend a minimum dual core Atom Processor system
  - 4GB RAM
  - 120GB SSD
- Burn ISO of PBX in a Flash, boot from it, and follow the install instructions
- Apache is installed by default

# How to Build (cont.)

- Openfire Chat:
  - XMPP (Jabber) protocol
  - If you are using PBX in a Flash: [www.pbxinaflash.org/piaf6/docs/install-openfire.pdf](http://www.pbxinaflash.org/piaf6/docs/install-openfire.pdf)
  - Can be configured to allow “self registration”
- Openfire was chosen due to logging capability
  - “Logs or it didn’t happen.”
  - Emergency response should have all activities logged
- Clients:
  - Any XMPP capable client
  - HIGHLY recommend Spark: <http://www.igniterealtime.org/downloads/index.jsp>

# How to Build it (cont.)

- Windows Workstation
  - Really?
    - Yes, really. Linux FTP server is a pain to get working (still haven't figured it out)
  - Install Filezilla server –DONE!
- Need to create a virtual web server in Apache to handle web requests to any other port that is not port 80. Recommend port 8080
  - Can do this in Webmin
- Point the following ports at your server: 21 TCP (FTP), 5060 UDP (VoIP), 8080 TCP (Web – Done by placing link on your node's page)

# Considerations

- Do I need all this power?
  - How many VoIP calls could possibly be needed at any moment?
- Do I need a VoIP server?
  - Maybe not.
  - Do you need voicemail?
    - Comes in handy if you are running emergency response / central command
  - Could program phone with one VoIP provider to enable you to dial out.
  - PBX in a Flash may be overkill for needs.
    - Provides voicemail and many advanced features.
      - Incredible PBX for Raspberry Pi may be for you
  - Can dial by IP address
    - Publish a directory of IP addresses (phonebook) in a text file on webserver



# Considerations (continued)

- Can I use any VoIP phone?
  - Yes, as long as it is SIP capable.
  - May want to consider VoIP adapters to use POTS phones.
    - POTS phone are likely to be more available during an emergency situation
  - Some Cisco phones may not work without a special flavor of the firmware on the phone
  - HIGHLY recommend Grandstream.
    - Inexpensive, \$60 for 5, 2 line phones on ebay
    - Easy to program
    - PoE Available on some models

# General Considerations

- I am not an attorney...
- Only licensed operators may use the equipment as you are likely exceeding FCC Part 15
- You cannot use encryption
  - Everything you do is in the clear text
  - You can authenticate users though

# Challenges & Solutions

- Network Access Control
  - Problem: Wireless access points issue IPs to anyone. Mesh firmware has no provisions to limit this.
  - Solution: Incompatible Access Points can be used.
    - Set to Access Point only mode
    - Disable DHCP
    - Use wired connection to configure
    - Lock wireless down to trusted devices by MAC address
    - Follow a standard naming convention: eg: KC3AAD-100-AP

# Challenges & Solutions (cont.)

- Centralized Services = Centralized Failure
  - Single point of failure
  - Distribute services across nodes
    - One piece of equipment running multiple services can stress it
    - Consider dedicating one or two services per server
  - Have backup hardware & software configurations
    - Hot-Hot Hardware
    - Cold Spares
  - Designate primary and secondary nodes for duplicate services
    - One service goes down, can transfer to another node with services
      - Configuration Management is going to be needed



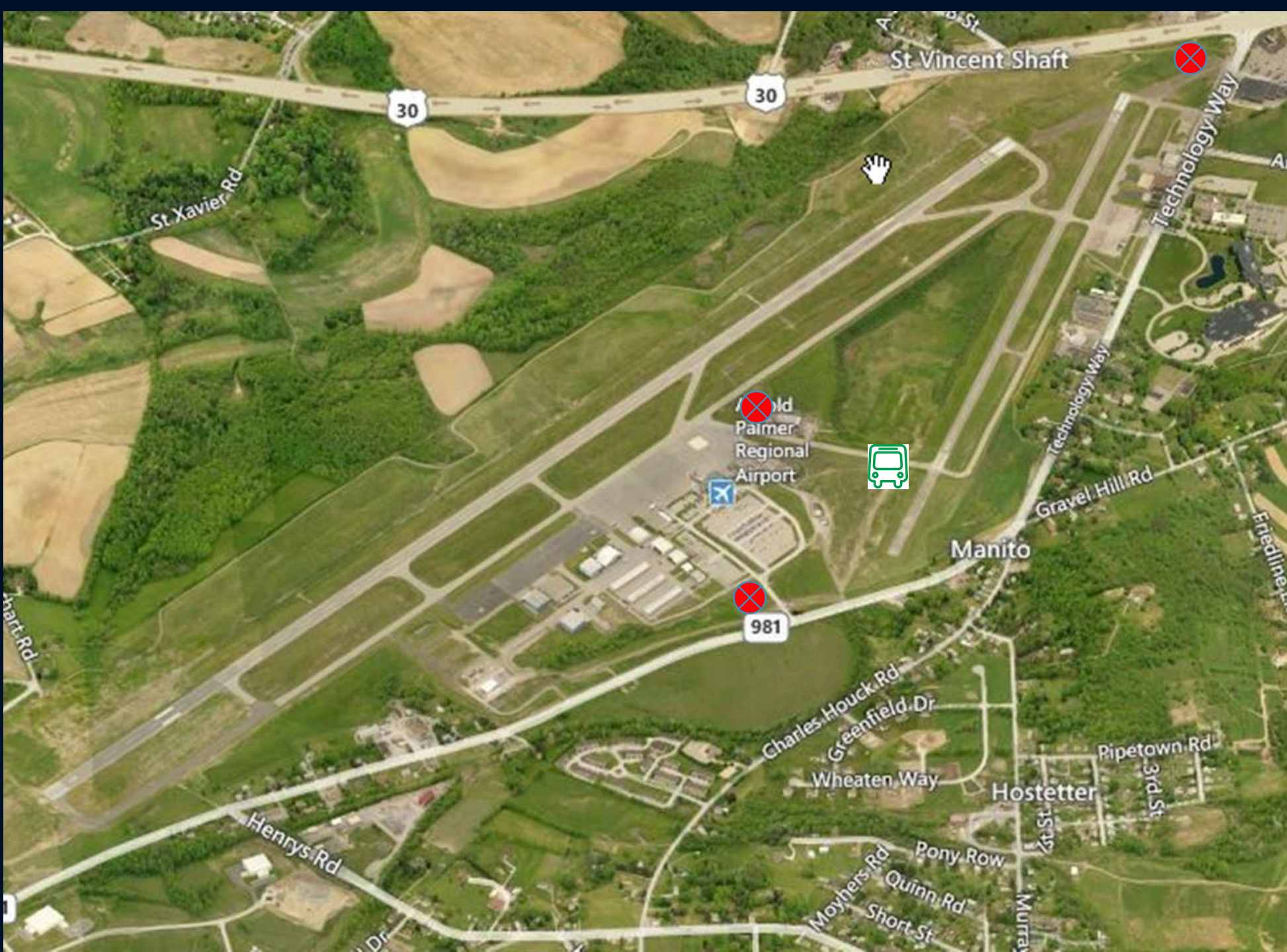
# Westmoreland County Airshow 2014

NOTES FROM THE BATTLEFIELD




# Latrobe Airport (LBE)

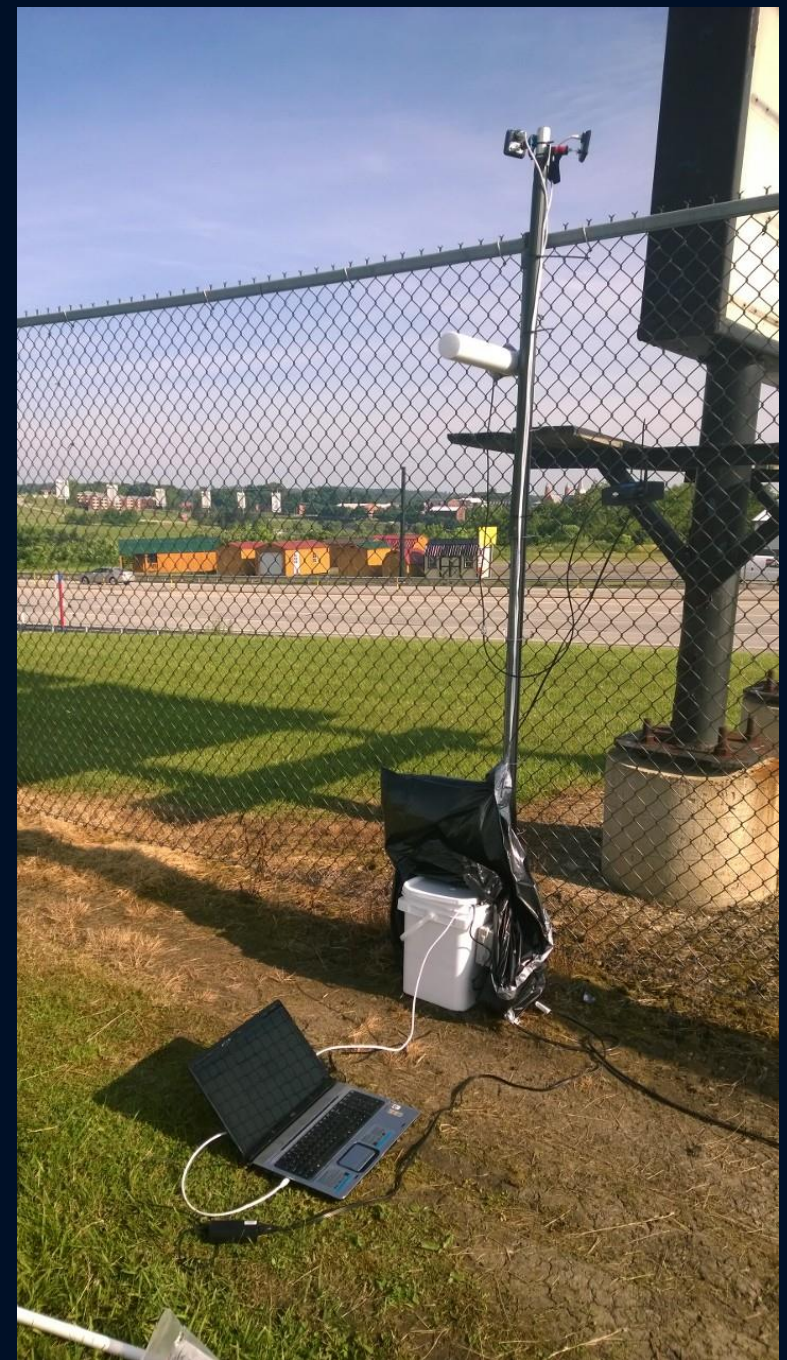
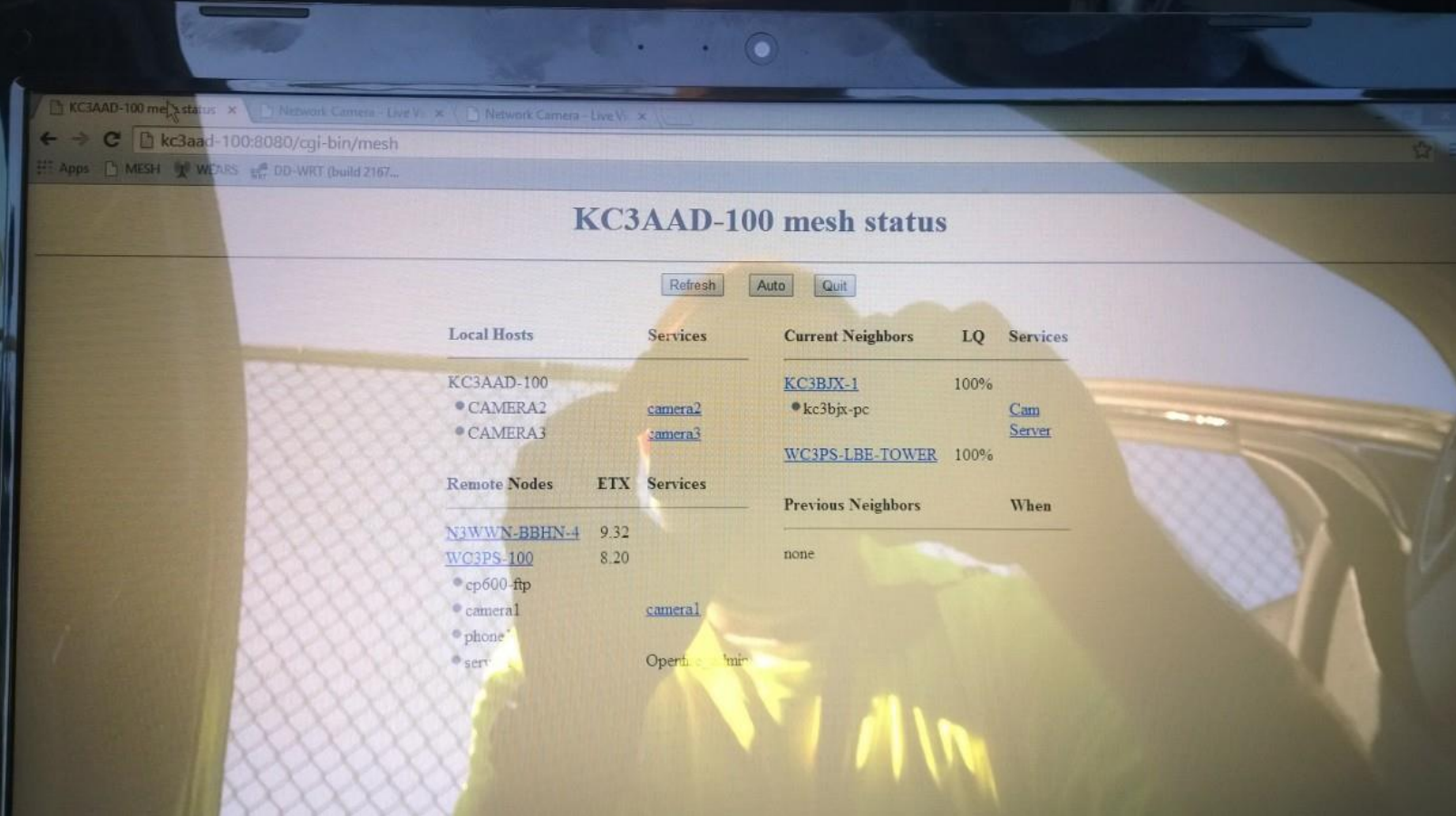




 = Mesh Node

 = CP600







# Lessons Learned

- Parabolic Dish Antennas are REALLY directional.
- Do not send a Linksys router to do a man's job.
  - Ubiquity gear rocks!
- If you are using 2.4GHz back hauls in a crowd of 50,000+ people with Smartphones beaconing, you're going to have a bad time.
  - Get your antennas up high
  - Use parabolic antennas aimed at omni-directional antennas for better performance.
  - Consider adding nodes in low coverage areas.

# Pro Tip: Tether your gear!

Tripod + High Gust Winds – Tethers  
= Broken Gear



# Lessons Learned (continued)

- Link quality is key when pushing video.
- You can never have enough 12 volt batteries.
- Have a Business Continuity Plan (BCP) / Disaster Recovery Plan (DR)
  - If it can fail, it will. – Diesel generator failure
- Have multiple methods of communication
  - Dedicated Simplex frequencies and a repeater were great
  - Instant messaging / chat / FTP can be a big help in an emergency



Future Work



# What's Next?

- Redesign some components of CP600 Network
  - Possibly move to a Windows System
  - 3CX Free Edition VoIP System
  - Filezilla FTP Server
- Westmoreland County Mesh Network
- Develop Standards, Policies, Documentation
- Create "Go Box" Self Contained Nodes
  - Set and forget
  - Give to anyone assisting in emergency

## What's Next? (cont.)

- RF maps of public places to assist in emergency response
- Field testing on-site of nodes where we may be called to
- Lots to do!

# Contact Information

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