SAR MESH
Advanced Networking

Special Presentation to the
2019 ASRC Winter Retreat

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Revision v0.0
Making a MESH of Things...

- What is this “MESH” technology? Where did it come from?
- Why does it matter, & how can the SAR Community leverage it?
- What Operational Mission Needs does it solve, and what new opportunities does it offer?
- What are MESH characteristics & capabilities?
- What can MESH do that we need, and other systems can’t, or are inadequate?
- How about Reliability, Availability, Flexibility, Security, and so many other needs & concerns?
- How difficult is it to setup and use?
- OK, so what’s it going to cost us to buy & maintain?
- Sooooo, what do we in the SAR Community do next to capture success??
Where Did “MESH” Come From?

Amateur Radio Emergency Data Network
The MAJOR Developer of the Revolutionary MESH Technologies is the ARDEN Community!!

Alerts
AREDN highly recommends upgrading to AREDN security release v3.18.9.0
For more information: https://www.arednmesh.org/content/aredn-v31890-available

News
AREDN Release Notes v3.18.9.0 – 26 September 2018

The AREDN team is pleased to announce the general availability of the latest stable release of AREDN firmware.

This release includes many significant improvements in the underlying OpenWRT code during the last 4 years, from July 2014 to August 2018. It also introduces a major upgrade in OLSR from version 0.6.7 to version 0.9.6.2.
Network Services
Connect the disaster area to the outside world

MESH (IP) Network Services!!
About that “MESH” Stuff...

- Excellent Characteristics for SAR:
  - Reliable, Flexible, Survivable, Robust...
  - Dynamic Configuration
  - Self Healing & Auto ReRerouting
  - Serves Mobiles in Motion, too!
  - Adapts to mitigate lost or failed Nodes
  - Especially Fault Tolerant
  - IF designed & implemented Right!

- What is this MESH technology?

- Compare to Other Known Systems?
  - Radios, Phones, Cellular, LANs, InterNet....
Already discussed earlier…

Bases, Mobiles, Handhelds…

Simplex, Duplex….

Relays, Repeaters, ReTransmitters...

Of course, IF the radio link dosen’t work, OR your radio fails, you’re Still Out of Luck!!

You DO have backup plans, don’t you?

Back to our MESH talk….. ;-)
Typical LANs plus Internet

LOTS OF SINGLE PATHS = EASY SINGLE POINT FAILURES!!
LANs with (MESH!!) Internet

LOTS OF SINGLE PATHS = EASY SINGLE POINT FAILURES!!

LOTS OF MULTIPLE PATHS = FEW SINGLE POINT FAILURES!!
Cellular Network (Mixed Cases)

MANY SINGLE PATHS = MANY SINGLE POINT FAILURES!!
The MESH Network

I NEED TO SEND SOME DATA...

WISH I HAD SOME DATA??
GLAD TO HELP MOVE YOUR DATA!!

Y'ALL ARE SO GREAT!!

LOOKS GOOD SO FAR!!

LOOKS GOOD HERE!!

GLAD TO HELP MOVE YOUR DATA!!
MESH AUTO RE-Routing

OUCH!!
I'M A DEAD NODE!!

IT'S OK!!
WE'LL GET YOUR MESSAGES THROUGH!!

GUYS!!
I NEED HELP!!

STILL LOOKS GOOD!!

IT'S OK!!
WE'LL GET YOUR MESSAGES THROUGH!!
MESH Magic Inside - OLSR
Optimum Link State Routing

Mesh Domain

Link Quality 80%
Path Cost 1.25

Link Quality 100%
Path Cost 1.00

Link Quality 45%
Path Cost 2.10

Link Quality 100%
Path Cost 1.00

Link Quality 100%
Path Cost 1.00
Typical MESH Gear

- **High Performance IP Based Data Networking** (10-100 Mbps throughput rates)
- Familiar Data Routers & Switches (typical IP based)
- Radio Nodes (any station) & Relays (combined stations)
- Operate in “MicroWave” bands (ISM ~2.4 & 5.9 Ghz) *(License-FREE!)*
- Flexible Links & Coverage (antenna selections)
  - Omnidirectional (area)
  - Directional (beaming)
- Great for leveraging high points with clear Radio Line of Sight (RLOS)
  - PLUS several options to beat pesky trees & foliage...
Typical MESH Gear

- Commercial grade durable equipment, but...
- Special “AREDN” MESH Software
- Simple configuration, most fully \textit{autonomous} \& \textit{automatic}
- Self Configuring, and \textit{Failure Tolerant}, including mobile movement, or node loss!
- Usually modest 12-24 VDC battery powered! (PoE)
- Can deploy chains of compact \& very capable \textit{“breadcrumb”} Relays!
- \textit{Excellent for Rapid Deployment to Remote Areas}
Preferred MESH Gear

Primarily Use Ubiquiti airMAX M-series WISP routers
- AirGrid
- AirRouter
- Bullet
- NanoBridge
- NanoStation
- Rocket

Robust Specifications
- Power Output: 23 - 28 dBm (200mW - 630mW)
- Antenna Gain: 11 - 30 dBi
- Temperature: -40° to 176°F
- Some configurations capable of 50+ mile range

Also support TP-Link Devices
- CPE210 & CPE510

Also the MikroTik Family of WISP Equipment
Tuvavco TP2458-13-40
13 dBi / 7dBi (?)
DualBand ~$45 total
~ 5” wide x 5.5” high

The INITIAL Remote Site Antennas For Most Links
Altelix AP5158
G23-NF
23 dBi
~$45 total
~ 12” wide x 12” high
(Hub INITIAL)

The BETTER
Hub & Remote Site
Antennas
For Most Links

Altelix AP5158G19M2-NF
19 dBi MIMO ~$45 total
~ 12” wide x 12” high
(Hub INITIAL)

Altelix AP5158G23-NF
23 dBi ~$45 total
~ 12” wide x 12” high

Cheap Note$!!
1- Ebay a bit better prices than Amazon…
2- Join others, buy in 5-packs!!
Altelix AG5158 Series
4.9-5.8 GHz Parabolic Grid Antennas
- Wide Multi-Band Coverage
- Vertical or Horizontal Polarization
- Low Wind Loading

Altelix AG5158G23-NF
24 dBi ~$45 total
~ 16” wide x 12” high

Altelix AG5158G27-NF
28 dBi ~$60 total
~ 24” wide x 16” high

Altelix AG5158G30-NF
30 dBi ~$70 total
~ 36” wide x 24” high

Cheap Note$!!
1- Ebay a bit better prices than Amazon…
2- Join others, buy in 5-packs!!

The BEST Hub & Remote Site Antennas For Longest Links
Deployable Node Examples

- Marine Corps Marathon 2018
- Tiny lunchbox size
- Battery box size
- Roller toolbox size (ICP flavored?)
- Small Deployable Hilltop Relays
- Others...
Marine Corps Marathon 2018 - Medical Data Net

ALPHA  NET (NCS)  BRAVO
Marine Corps Marathon 2018 - Medical Data Net

DELTA  ECHO
Trevor’s Portable MESH Node 1

http://www.trevorsbench.com/portable-internet-mesh-node/
Trevor’s Portable MESH Node 2

Trevor’s Portable MESH Node 2
Trevor’s Portable MESH Node 2
“Stanley” MESH GO-KIT

https://www.arednmesht.org/content/please-meet-stanley
“Stanley” MESH GO-KIT

https://www.arednmesh.org/content/please-meet-stanley
“Stanley” MESH GO-KIT

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“Stanley” MESH GO-KIT

https://www.arednmesh.org/content/please-meet-stanley
MESH Small Hilltop Relays

Small Footprints / Wide Coverage
Saddleback Peak - Mission Viejo, CA
MESH Deployed Mobile Nodes
Where Can MESH Work?

- *Almost everywhere!* *IF* done *Right…!*

- BUT *best* to *PrePlan* known or anticipated Operational Missions, Response Areas & Sites.

Field Test: Reston Town Center
Central PA IP Network (CPIPN)
Mid Atlantic IP Network (MAIPN)
Mid Atlantic IP Network (MAIPN)

TO RED LION, PA
(BRIDGE TO CPIPN)

Frederick

Baltimore

Washington

MAIPN NETWORK MAP
OCTOBER 2018
Existing NoVa Area MESH

North Mountain Rptr Site (W4RKC-NMT)

Winchester

John-N9ZL
Royce-W3IF
Tim-K3Xl
Dave-WA4DJ
Tom-N4QLM
Mike-AB4YY
Jim-WD4OJY
Jerry-N04N
Ken-KE2N (Watts-K4OJZ)

Leesburg

Bull Run Mountain Ken-KE2N

Stephens City

Tom-AF2D
SMS (Skyline Middle School)

Manassas

Our Mesh Network - Current Overall View
March 18, 2018 AB4YY

15 Locations Connected
No Internet Gateways Permitted
Time Server (N4QLM): "Service_FrontRoyal"
Shenandoah Valley side SSID: AREDN_FrontRoyal
Shenandoah Valley side Frequency: Ch.-2 (2.397 MHz), 10 MHz BW
IP Phones: 10+
IP Cameras: 3
Web Server: 1
MeshChat: 2 (messages synchronized)
File Server: 1 (on RPI w/MeshChat)
Direct Connected BPQ Packet Nodes: 5

NoVa MESH EXISTING NODES Near NoVa Region
Bears Den - Omni

- Link Distance: 27.38 mi
- Site RX Signal: -83.31 dBm
- Station RX Signal: -83.31 dBm
- Total Capacity: 27.3 Mbps, 5%

Mesh Nodes:
- Luray
- Manassas
- Winchester
- BEARS DEN

Mesh Nodes (locations):
- Frederick
Bears Den - West

North Mtn. MESH NODE

Winchester

MESH NODES

Stephens City

MESH NODE

BEARS DEN
Bears Den – Stephens City

MESH Link K4AEA to Bears Den
MESH Link K4AEA Stephens City to Bears Den Bluemont
18.4 miles East 84 degrees

Winchester

MESH NODE

Stephens City

BEARS DEN

18.4 miles
Bears Den – Bull Run Mtn.

MESH Link Bears Den Bluemont to KE2N Bull Run Mt

- Distance: 18.5 miles
- Direction: Southeast 141 degrees
- Note: 1440 feet crest of Blue Ridge, just East of Bears Den
Bears Den – SouthWest

(Vertical scale exaggerated 7.2x)

- Stephens City
- North Mtn.

Mesh nodes

Show 0° and 1° alt
References

- arrl.org (Hams & lots of clues!)
- www.ardenmesh.org (THE Source!)
- www.youtube.com (lots of info!)
- maipn.org (MAIPN)
- AREDN –Marine Corp Marathon 2018 Results - Mark Braunstein WA4KFZ
- Mesh Networking -Mathison Ott KJ6DZB
- Building a High-Speed AuxCommData Network – Hansen Andre K6AH
- (Lots more!)
Summary

- The AREDN MESH Technologies offer an excellent suite of capabilities, and superior performance, to benefit many SAR and Other Operational Mission Needs.

- MESH is rapidly evolving, with improved features and functions.

- MESH is also Ready for “Prime Time”

- It is already being deployed and leveraged by multiple other Organizations.

- For SAR and Other Mission use, many systems available for our use, and we are Welcome!

- We in SAR need to coordinate & contribute, plus develop our own Unique plus Interoperable Protocols and Equipment.

- Our Companions in the MESH Community are already building out multiple Regional and Local MESH Systems.
Recommendations

- We need a SAR MESH Working Group to pursue these opportunities
- And in close coordination with SAR Leadership, Operations, and Communications Stakeholders.
- As an early step, conduct a more detailed briefing and training, with hands-on orientation and operation of actual MESH equipment.
- Jointly develop a CONOPS, plus preliminary Planning for Adoption
- As a follow-on step, build and exercise several deployable MESH Nodes (for ICPs etc), plus a few Tactical MESH Relays (for “breadcrumbs”).
Recommendations

- Coordination & cooperation with adjacent systems (NoVA-MESH, CPIPN, MAIPN…) in and around our SAR Operational Regions.

- Collect data & do planning for existing/potential SAR-friendly MESH Sites

- Other Steps?

- Ideas for hot candidate sites?

- Ideas for other Stakeholders & User Organizations?

- Other useful tools?
Questions??

Demonstrations?

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