The European HAMNET
A large scale high speed radio network

Jann Traschewski, DG8NGN
German Amateur Radio Club (DARC e.V.)
dg8ngn@darc.de

http://hamnetdb.net → Map
db0fhn:~$ whois dg8ngn

- VHF/UHF/Microwave Manager DARC e.V.
- Active in Frequency Management DARC e.V.
- 44Net IP-Coordination Team, Germany
  (Thomas, DL9SAU / Egbert, DD9QP / Jann, DG8NGN)
- One of the founders of the D-Star ircDDB network
  (Hans-Jürgen, DL5DI / Michael, DL1BFF / Jann, DG8NGN)

- Profession: System Engineer for Spectrum Monitoring Systems at Rohde & Schwarz Munich
Abstract

The HAMNET is a high speed amateur radio multimedia network based on commercial wireless devices using mainly the 6cm band.

It covers mostly the German speaking region in Europe and is about to grow over the language border.

It is using the international coordinated IP-address space of the AMPRNet (44.0.0.0/8) and AS numbers out of the 16-bit and 32-bit private AS number space to interconnect active regions by external BGP routing.

This paper documents how this network has been deployed and how it is interconnected with the international AMPRNet and the Packet Radio World.

It will show which tools have been developed and customized for link planning, spectrum and network management.

Moreover it will show the challenges we meet with authentication, spectrum regulatory questions and non-line-of-sight wireless user access.

Finally the vision of a huge intranet for radio amateurs with end-to-end communication capabilities will be presented.
The network
Standard Deployment Example

Mikrotik

- 2.3 GHz User Access Antenna
  - ~20 $
- 2.3 GHz user access trx
  - Mikrotik Metal 2SHPn
  - ~99 $
- 5 GHz mid range link antenna (MIMO)
  - Mikrotik QRT-5
  - ~169 $
- 5 GHz long range link antenna (MIMO)
  - Mikrotik mANT30 PA
  - ~129 $
- 5 GHz trx (MIMO)
  - Mikrotik BaseBox5
  - ~89 $
- 5 GHz trx (MIMO)
  - Mikrotik RB750UP
  - ~59 $

23dBi

LAN+PoE

30dBi
Standard Deployment Example
Ubiquiti User Access

- 5 GHz user access antenna (MIMO) + trx
- Ubiquiti Nanostation M5 ~90 $ each

North
East
South
West

16dBi
up to
27dBm

LAN+PoE
LAN+PoE
LAN+PoE
LAN+PoE

Switch with 4x PoE out
Mikrotik RB260GSP
~55,95 $
Network Management – Principles & IP Allocations

- Keeping the experimental nature of amateur radio
  - Regional network management
  - Active regions will get enough resources (IP-addresses, AS-numbers)
  - Active regions will „speak“ eBGP to neighbors
- IP numbers for German regions will be provided by the German IP coordination team

<table>
<thead>
<tr>
<th>Network</th>
<th>Country</th>
<th>Co-Ordinator</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.0.0.0/8</td>
<td>Global</td>
<td>WB6CYT [Brian Kantor]</td>
</tr>
<tr>
<td>44.130.0.0/16</td>
<td>GERMANY</td>
<td>DG8NGN [Jann Traschewski]</td>
</tr>
<tr>
<td>44.224.0.0/15</td>
<td>GERMANY</td>
<td>DG8NGN [Jann Traschewski]</td>
</tr>
</tbody>
</table>

https://portal.ampr.org/networks.php
Network Management – ASN allocations (16 bit)

- The HAMNET is using the private AS space as noted in RFC 1930 (AS64512 to AS65535)

RFC 1930 Guidelines for creation of an AS March 1996

10. Reserved AS Numbers

The Internet Assigned Numbers Authority (IANA) has reserved the following block of AS numbers for private use (not to be advertised on the global Internet):

64512 through 65535
Network Management – ASN allocations (16 bit)

- The allocation to different countries is not yet coordinated in a global way, thus we try to synchronize our wikis with recent changes:
  - DL: http://www.de.ampr.org/dokumentation/as-nummern

<table>
<thead>
<tr>
<th>Country</th>
<th>ASN Block</th>
<th>local documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>OE Austria</td>
<td>64512-64599</td>
<td>Wiki</td>
</tr>
<tr>
<td>I Italy</td>
<td>64600-64619</td>
<td>Wiki</td>
</tr>
<tr>
<td>DL Germany</td>
<td>64620-64683</td>
<td>List or WHOIS-Search</td>
</tr>
<tr>
<td>LX Luxemburg</td>
<td>64684-64685</td>
<td>Wiki</td>
</tr>
<tr>
<td>CR Croatia</td>
<td>64686-64690</td>
<td>Wiki</td>
</tr>
<tr>
<td>PA Netherlands</td>
<td>64691-64694</td>
<td>Wiki</td>
</tr>
<tr>
<td>S5 Slovenia</td>
<td>64695-64704</td>
<td>Wiki</td>
</tr>
<tr>
<td>HA Hungary</td>
<td>64705-64707</td>
<td>Wiki</td>
</tr>
<tr>
<td>EA Spain</td>
<td>64708-64719</td>
<td>Wiki</td>
</tr>
<tr>
<td>HB Switzerland</td>
<td>64720-64739</td>
<td>Wiki</td>
</tr>
<tr>
<td>HB0 Liechtenstein</td>
<td>64740-64741</td>
<td>Wiki</td>
</tr>
<tr>
<td>F France</td>
<td>64742-64777</td>
<td>Wiki</td>
</tr>
<tr>
<td>ON Belgium</td>
<td>64778-64788</td>
<td>Wiki</td>
</tr>
<tr>
<td>TA Turkey</td>
<td>64789-64799</td>
<td>Wiki</td>
</tr>
<tr>
<td>SP Poland</td>
<td>64800-64839</td>
<td>Wiki</td>
</tr>
<tr>
<td>YO Romania</td>
<td>64840-64849</td>
<td>Wiki</td>
</tr>
<tr>
<td>* Test and BGP-Confederations</td>
<td>65510-65534</td>
<td>Wiki</td>
</tr>
</tbody>
</table>
Network Management – ASN allocations (32 bit)

- The amateur radio community requested a private AS number block within the 32 bit range
- RFC 6996 reflects the new private AS number block 4200000000 to 4294967294
- No coordination – just experiments and thoughts how to coordinate

RFC 6996

Private Use AS Reservation

July 2013

5. IANA Considerations

IANA has reserved, for Private Use, a contiguous block of 1023 Autonomous System numbers from the "16-bit Autonomous System Numbers" registry, namely 64512 - 65534 inclusive.

IANA has also reserved, for Private Use, a contiguous block of 94,967,295 Autonomous System numbers from the "32-bit Autonomous System Numbers" registry, namely 4200000000 - 4294967294 inclusive.

These reservations have been documented in the IANA "Autonomous System (AS) Numbers" registry [IANA.AS].
Routing within a region

- Each region is free to use its favorite routing protocol (e.g. OLSR, B.A.T.M.A.N., OSPF, internal BGP)
- Internal BGP is often used
  - Full Mesh: Each node needs to talk to each other node (more traffic, does not scale → \( n(n-1)/2 \) BGP links necessary)
  - Route Reflector: Each node needs to talk to the route reflector (Single point of failure)
  - BGP Confederation: ASN block 65510 to 65534 is used as internal AS numbers
Deployment - Sites

- Get in touch with anybody on this site: http://hamnetdb.net/?m=util&func=maintainer

Maintainers with write-access in this database:

<table>
<thead>
<tr>
<th>Callsign</th>
<th>Full Name</th>
<th>Comment</th>
<th>Edited</th>
</tr>
</thead>
<tbody>
<tr>
<td>db1hdn</td>
<td>Dennis</td>
<td>Admin DB0ROW, DB0RTN</td>
<td>364d dh6bb</td>
</tr>
<tr>
<td>db5jl</td>
<td>Detlev</td>
<td>C21</td>
<td>536d dg8ngn</td>
</tr>
<tr>
<td>db7mj</td>
<td>Peter</td>
<td>Sysop DB0ESS</td>
<td>477d dl8mbt</td>
</tr>
<tr>
<td>db7yi</td>
<td>Michael</td>
<td>Sysop DB0PM</td>
<td>595d dg8ngn</td>
</tr>
<tr>
<td>db8zp</td>
<td>Peter</td>
<td>Sysop DB0TAN</td>
<td>403d dg8ngn</td>
</tr>
<tr>
<td>dc1dmr</td>
<td>Matti</td>
<td></td>
<td>92d dh3wr</td>
</tr>
<tr>
<td>dc1nf</td>
<td>Dieter</td>
<td>Sysop DB0ADS</td>
<td>303d dg8ngn</td>
</tr>
<tr>
<td>dc1paa</td>
<td>Michael</td>
<td>Sysop DB0ALU</td>
<td>557d dg8ngn</td>
</tr>
<tr>
<td>dc1rd</td>
<td>Rainer</td>
<td>Sysop DB0SL</td>
<td>423d dg8ngn</td>
</tr>
<tr>
<td>dc2ve</td>
<td>Frank</td>
<td>Verwaltung AS64650</td>
<td>538d dg8ngn</td>
</tr>
<tr>
<td>dc4ah</td>
<td>Andreas</td>
<td>Sysop DB0UNIX</td>
<td>293d dk2crn</td>
</tr>
</tbody>
</table>

- They can create an account for you to edit the database
- Or ask me (dg8ngn@darc.de) to get you an account
Deployment - Sites

- Login to http://hamnetdb.net
- Click on „Sites“
- Press „New Site“
- Fill the following data into the form:
  - Call sign
  - Descriptive Name
  - Latitude, Longitude and meters above ground
  - Comma separated list of maintainers
Deployment - Sites

- Click onto your site and scroll down the list
- Have a look for nearby sites and check the link profile by clicking „Profile“
- Check for line of sight (5 GHz) and get in touch with the operator
Deployment – Link Budget

• You might want to calculate your link budget to estimate the data rate you could achieve

• Check your data sheet of your TRX (e.g. Mikrotik QRT 5)
  → Gain is 23 +/- 1dBi

<table>
<thead>
<tr>
<th>TX/RX at MCS0</th>
<th>TX power / RX sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>TX/RX at MCS7</td>
<td>24dBm / -78dBm</td>
</tr>
<tr>
<td>TX/RX at 6Mbit</td>
<td>30dBm / -96dBm</td>
</tr>
<tr>
<td>TX/RX at 54Mbit</td>
<td>27dBm / -80dBm</td>
</tr>
<tr>
<td>Frequency range</td>
<td>4900-5920MHz</td>
</tr>
</tbody>
</table>

  → TX level at MCS7 (Modulation and Coding Scheme: 64-QAM with Coding rate 5/6) will be 24dBm

  → RX at MCS7 needs -78dBm of receiving power level

• Check additional losses of antenna gain by looking into chart „gain vs. frequency“ (if provided by manufacturer)
Deployment – Link Budget

- There are many link budget calculation tools on the web
- Pick one and put the worst case values in (e.g. http://en.jirous.com/calculation-wifi):

Fresnel zone

Fresnel zone is an area where most of the power between antennas is transmitted, it is cigar shaped. If there is a barrier in this area, the transmission attenuation increases. Calculated radius is in the middle of the link and at the end it decreases.
Deployment – Link Budget

- Estimated receiving level is -71dBm, so we have 7dB left for inaccuracy (e.g. unknown frequency/gain behavior)
- Keep in mind that changing bandwidth from 20 MHz down to 10 MHz will give you 3dB more gain (respectively 6dB by narrowing down to 5 MHz) but the throughput will suffer from the same factor (divided by 2 respectively 4)
- Running 2 spatial streams (horizontal and vertical polarization) at the same time will give us 130 Mbit/s:

<table>
<thead>
<tr>
<th>MCS index</th>
<th>Spatial streams</th>
<th>Modulation type</th>
<th>Coding rate</th>
<th>Data rate (Mbit/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20 MHz channel</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>800 ns GI</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>64-QAM</td>
<td>5/6</td>
<td>65.00</td>
</tr>
<tr>
<td>15</td>
<td>2</td>
<td>64-QAM</td>
<td>5/6</td>
<td>130.00</td>
</tr>
</tbody>
</table>

Deployment – Spectrum Regulatory

- Before deploying a radio link you need to check the rules which apply for your country
- Germany
  - Automatic radio stations need a special license (they get a special call sign e.g. „db0xyz“) from the regulation authority „BNetzA“ (200,- € per call sign)
  - Different rules will apply per band or even frequency ranges (e.g. max. 15W ERP >30 MHz and 10 MHz bandwidth maximum) by law
Deployment – Spectrum Allocation Status

● On the most GHz bands we do only have secondary status and need to take care that the primary user will not be disturbed

● Germany
  – If applying for a license the regulatory authority will send a request to the primary user
  – If the primary user is fine with the planned frequency usage a permission will be given by the regulatory authority (takes currently around 4 to 5 months)
Deployment – Spectrum Sharing

- **Sharing with Wifi (Germany)**

<table>
<thead>
<tr>
<th>Amateur</th>
<th>Wifi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. 15W ERP</td>
<td>Max. 1W ERP (if DFS „Dynamic Frequency Selection“ and TPC „Transmit Power Control“ is used)</td>
</tr>
<tr>
<td>Need special License</td>
<td>No license necessary</td>
</tr>
<tr>
<td>Bandwidth limited</td>
<td>40 MHz and more</td>
</tr>
<tr>
<td>Further Restrictions and Rules (need to identify, no encryption, limited content)</td>
<td>Radar Detection must be implemented in the upper 5 GHz band</td>
</tr>
</tbody>
</table>

**Question:** Is it all worth just for 12dB more gain considering that most of the wifi networks doesn't take care on DFS, TPC and Radar Detection?
Deployment – Spectrum Sharing

- Sharing with Radars is possible due to spectrum management (license for radio links only if primary user has agreed)

  Wifi emissions without radar detection disturbing weather radars...

  Rain: Romania
  Wifi: Slovakia and Poland

http://www.radareu.cz
Deployment – Spectrum Sharing

• Sharing with other Amateur Radio Applications
  – Have a look into the IARU Band plan
  – Have a look into your national Band plan

• Germany
  – We are running different kind of digital links (Digital ATV, Packet Radio, HAMNET)
  – The Band plan should specify „bandwidth“ for certain frequencies rather than „application types“ to be able to consolidate the applications
  – e.g. DATV-links can carry TCP/IP, HAMNET can carry IPTV and Packet Radio → Build a large backbone for any kind of amateur application
Deployment - Identification

- Radio amateurs need to identify in regular intervals
  
  - ESSID (e.g. HAMNET-DB0ABC-DB0XYZ)

- But is a transmission coming from DB0ABC or DB0XYZ?
  → Only valid with fixed convention (e.g. AP-Mode = first call sign and Station-Mode = second call sign)
  → How to handle Point-to-Multpoint Links?
Deployment - Identification

- Using locally administered MAC-addresses
  - Encoding of call sign into the free bits in a MAC-address

```
8 Bit 1 8 Bit 1 8 Bit 1 8 Bit 1 8 Bit 1 8 Bit 1
RRRRRRXX RRRRRRNN RRRRRRSS RRRRRRSS RRRRRRSS RRRRRRSS
```

\[ R = \text{Bits for coding the call sign} \]
\[ S = \text{Bits for the station identifier (SSID)} \]
\[ N = \text{reserved for future applications} \]
\[ X = \text{Standardbits according to IEEE 802} \]
  - Bit 1: 0 = unicast / 1 = multicast
  - Bit 2: 0 = globally unique / 1 = locally administered

Details and Tools/Scripts available (in German) on:
http://db0fhn.efi.fh-nuernberg.de/doku.php?id=projects:wlan:proposal
Deployment - Identification

- Neighbor Discovery Protocols
  - There are plenty of neighbor discovery protocols in the wild (CDP, LLDP, MNDP, ...)
  - Just set the „Identity“ to your call sign and you're fine

Neighbor List of HAMNET Station „DB0DOS“
(Mikrotik and Ubiquiti Devices)
Deployment – AS/IP-Subnet-Allocation

- Regions need to get an AS- and IP-Allocation
  - The German IP Coordination is taking care

```
# ------------
# HAMNET-DL
# -----------
# AS- AS- NETWORKS NETWORKS NETWORKS
# NO NAME BACKBONE USER/SERVICES PACKET-RADIO
# 64625 DISTRIKT-C-625-AS 44.224.10.0/23 44.225.20.0/22 44.130.56.0/24
# 64626 DISTRIKT-B-626-AS 44.224.12.0/23 44.225.24.0/22 44.130.60.0/24
# 64627 DISTRIKT-L-627-AS 44.224.14.0/23 44.225.28.0/22 44.130.146.0/24
# 64629 DISTRIKT-D-629-AS 44.224.18.0/23 44.225.32.0/22 44.130.56.0/24
# 64630 DISTRIKT-U-630-AS 44.224.20.0/23 44.225.40.0/22 44.130.59.0/24
# 64631 DISTRIKT-T-631-AS 44.224.22.0/23 44.225.44.0/22 44.130.61.0/24
```

http://www.de.ampr.org/dokumentation/as-nummern/as-list-de
Deployment – AS-Allocation

- Information is reflected in the HAMNETDB

http://hamnetdb.net/?m=as
Deployment – IP-Subnet-Allocation

- Information is reflected in the HAMNETDB

<table>
<thead>
<tr>
<th>Subnet-IP</th>
<th>Type</th>
<th>Own AS</th>
<th>Parent</th>
<th>Radio parameters / Comment</th>
<th>Edited</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.130.53.0/24</td>
<td>AS-Packet-Radio</td>
<td>-</td>
<td>AS64531</td>
<td></td>
<td>393d dg8ngn</td>
</tr>
<tr>
<td>44.130.56.0/24</td>
<td>AS-Packet-Radio</td>
<td>-</td>
<td>AS64625</td>
<td></td>
<td>393d dg8ngn</td>
</tr>
<tr>
<td>44.130.59.0/24</td>
<td>AS-Packet-Radio</td>
<td>-</td>
<td>AS64530</td>
<td></td>
<td>393d dg8ngn</td>
</tr>
<tr>
<td>44.130.60.0/24</td>
<td>AS-Packet-Radio</td>
<td>-</td>
<td>AS64626</td>
<td></td>
<td>393d dg8ngn</td>
</tr>
<tr>
<td>44.130.61.0/24</td>
<td>AS-Packet-Radio</td>
<td>-</td>
<td>AS64531</td>
<td></td>
<td>393d dg8ngn</td>
</tr>
<tr>
<td>44.130.99.0/24</td>
<td>AS-Packet-Radio</td>
<td>-</td>
<td>AS64626</td>
<td></td>
<td>186d dg8ngn</td>
</tr>
<tr>
<td>44.130.146.0/24</td>
<td>AS-Packet-Radio</td>
<td>-</td>
<td>AS64527</td>
<td>Distrikt-L Packet-Radik Netz</td>
<td>162d dd9qp</td>
</tr>
<tr>
<td>44.224.10.0/23</td>
<td>AS-Backbone</td>
<td>-</td>
<td>AS64625</td>
<td></td>
<td>665d dg8ngn</td>
</tr>
<tr>
<td>44.224.12.0/23</td>
<td>AS-Backbone</td>
<td>-</td>
<td>AS64526</td>
<td></td>
<td>594d dg8ngn</td>
</tr>
<tr>
<td>44.224.14.0/23</td>
<td>AS-Backbone</td>
<td>-</td>
<td>AS64627</td>
<td>Distrikt-L Backkbone Netz</td>
<td>579d dg8ngn</td>
</tr>
<tr>
<td>44.224.16.0/23</td>
<td>AS-Backbone</td>
<td>-</td>
<td>AS64528</td>
<td></td>
<td>594d dg8ngn</td>
</tr>
<tr>
<td>44.224.18.0/23</td>
<td>AS-Backbone</td>
<td>-</td>
<td>AS64629</td>
<td>Berlin Backbone Netz</td>
<td>585d dl7uaz</td>
</tr>
<tr>
<td>44.224.20.0/23</td>
<td>AS-Backbone</td>
<td>-</td>
<td>AS64530</td>
<td></td>
<td>594d dg8ngn</td>
</tr>
<tr>
<td>44.224.22.0/23</td>
<td>AS-Backbone</td>
<td>-</td>
<td>AS64531</td>
<td></td>
<td>594d dg8ngn</td>
</tr>
<tr>
<td>44.225.20.0/22</td>
<td>AS-User/Services</td>
<td>-</td>
<td>AS64525</td>
<td></td>
<td>689d dl8mbt</td>
</tr>
<tr>
<td>44.225.24.0/22</td>
<td>AS-User/Services</td>
<td>-</td>
<td>AS64626</td>
<td></td>
<td>594d dg8ngn</td>
</tr>
<tr>
<td>44.225.28.0/22</td>
<td>AS-User/Services</td>
<td>-</td>
<td>AS64627</td>
<td>Distrikt-L User/Services Netz</td>
<td>579d dd9qp</td>
</tr>
<tr>
<td>44.225.32.0/22</td>
<td>AS-User/Services</td>
<td>-</td>
<td>AS64628</td>
<td></td>
<td>594d dg8ngn</td>
</tr>
<tr>
<td>44.225.36.0/22</td>
<td>AS-User/Services</td>
<td>-</td>
<td>AS64629</td>
<td>Berlin User-Service Netz</td>
<td>456d dl9sau</td>
</tr>
<tr>
<td>44.225.40.0/22</td>
<td>AS-User/Services</td>
<td>-</td>
<td>AS64530</td>
<td></td>
<td>688d dl8mbt</td>
</tr>
<tr>
<td>44.225.44.0/22</td>
<td>AS-User/Services</td>
<td>-</td>
<td>AS64531</td>
<td></td>
<td>688d dl8mbt</td>
</tr>
</tbody>
</table>

http://hamnetdb.net/?m=subnet
Deployment – „IP-Subnetting“

- Each region gets a /23 for the backbone (transfer networks) and a /24 for user-/services (site networks)

- Best practice:
  - Each site has a single router
  - Each site gets a /27 network from the maintainer (leave the next /27 free in case a network needs to be increased)
  - The sitenetwork will be announced by the router to the network
  - The sitenetwork can be splitted „internally“ at the site into several networks (e.g. /28 for users and /28 for services) → easy firewalling
  - Each site uses a /29 transfer network to interconnect to another site
The HAMNETDB provides network management capabilities.

Data structure (AS, Hosts, Subnets, Sites):
- Hosts belong to sites (user defined)
- Hosts belong to subnets (by nature)
- Subnets belong to AS (user defined)

→ The HAMNETDB is able to visualize data
Deployment – Network Documentation Example

### Site db0zm (München-Freimann Studentenstadt)

- **Coordinates:** 48.184086,11.611249 - 48°11.05' N 11°36.67' E - 48°11.02' N 11°36.40' E
- **Elevation:** 65 m above ground
- **Maintainer:** dl8rds, dg8ngn, dl8mbt, dd5ki

Am Standort ist auch:
- 2m FM Relais DB0ZM 145.750
- 70cm FM-Relais DB0NJ 438.775
- 70cm DMR-Relais DB0NJ 439.4375
- 2 Kameravon [http://www.foto-webcam.eu](http://www.foto-webcam.eu)

**Site configuration:** [https://www.dropbox.com/s/0sd219kow4lb23f/DB0ZM.gif](https://www.dropbox.com/s/0sd219kow4lb23f/DB0ZM.gif)

**Last edited 2013-12-07 by dl8mbt**

<table>
<thead>
<tr>
<th>Site</th>
<th>Coordinates</th>
<th>Backbone Network</th>
<th>Station WDS</th>
<th>AP Bridge</th>
<th>Distance</th>
<th>Linktool</th>
</tr>
</thead>
<tbody>
<tr>
<td>db0zm</td>
<td>44.224.10.49</td>
<td>44.224.10.48/29</td>
<td>NStreme</td>
<td>000c423a644c</td>
<td>5685MHz, 10MHz, horizontal</td>
<td><img src="https://www.dropbox.com/s/0sd219kow4lb23f/DB0ZM.gif" alt="Linktool" /></td>
</tr>
<tr>
<td>db0tvm</td>
<td>44.224.10.54</td>
<td>44.224.10.40/29</td>
<td>NStreme</td>
<td>000b6b234bca</td>
<td>5825MHz, 10MHz, horizontal</td>
<td><img src="https://www.dropbox.com/s/0sd219kow4lb23f/DB0ZM.gif" alt="Linktool" /></td>
</tr>
<tr>
<td>db0wai</td>
<td>44.224.10.41</td>
<td>44.224.10.72/29</td>
<td>NStreme</td>
<td>000c4260f560</td>
<td>5795MHz, 10MHz, vertical</td>
<td><img src="https://www.dropbox.com/s/0sd219kow4lb23f/DB0ZM.gif" alt="Linktool" /></td>
</tr>
<tr>
<td>db0ebe</td>
<td>44.224.10.78</td>
<td>44.224.10.72/29</td>
<td>NStreme, 23dBi</td>
<td>000c426fb3f2</td>
<td>28.0km - 111.8°</td>
<td><img src="https://www.dropbox.com/s/0sd219kow4lb23f/DB0ZM.gif" alt="Linktool" /></td>
</tr>
</tbody>
</table>
### Deployment – Network Documentation Example

<table>
<thead>
<tr>
<th>Host-IP</th>
<th>Hostname</th>
<th>Type</th>
<th>Site</th>
<th>Radio parameters / Comment</th>
<th>Edited</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.224.10.46</td>
<td>bb-db0wai.db0zm</td>
<td>Routing-Radio</td>
<td>db0zm</td>
<td>Station WDS (NStreme)</td>
<td>584d dg8ngn</td>
</tr>
<tr>
<td>44.224.10.49</td>
<td>bb-db0tvm.db0zm</td>
<td>Routing-Radio</td>
<td>db0zm</td>
<td>Station WDS (NStreme)</td>
<td>584d dg8ngn</td>
</tr>
<tr>
<td>44.224.10.73</td>
<td>bb-db0ebe.db0zm</td>
<td>Routing-Radio</td>
<td>db0zm</td>
<td>Station WDS (NStreme)</td>
<td>378d dg8ngn</td>
</tr>
<tr>
<td>44.224.10.74</td>
<td>lnk-db0ebe.db0zm</td>
<td>Service</td>
<td>db0zm</td>
<td></td>
<td>584d dg8ngn</td>
</tr>
<tr>
<td>44.225.20.193</td>
<td>router.db0zm</td>
<td>Service</td>
<td>db0zm</td>
<td>Routerboard RB433AH (WAI, TVM)</td>
<td>584d dg8ngn</td>
</tr>
<tr>
<td>44.225.20.194</td>
<td>allstarlink.db0zm</td>
<td>Service</td>
<td>db0zm</td>
<td>2m FM-Relais DB0ZM</td>
<td>667d dg8ngn</td>
</tr>
<tr>
<td>44.225.20.195</td>
<td>eop.db0zm</td>
<td>Service</td>
<td>db0zm</td>
<td>Routerboard RB411AH (EBE)</td>
<td>667d dg8ngn</td>
</tr>
<tr>
<td>44.225.20.196</td>
<td>hamnetdb.db0zm</td>
<td>Service</td>
<td>db0zm</td>
<td>Raspberry PI mit Debian - ProxyPa..</td>
<td>506d dl8mbt</td>
</tr>
<tr>
<td>44.225.20.197</td>
<td>webcam-nord.db0zm</td>
<td>Service</td>
<td>db0zm</td>
<td>Kamerarechner WL500GP OpenWRT - h..</td>
<td>589d dl8mbt</td>
</tr>
<tr>
<td>44.225.20.198</td>
<td>webcam-sued.db0zm</td>
<td>Service</td>
<td>db0zm</td>
<td>Kamerarechner WL500GP OpenWRT - h..</td>
<td>589d dl8mbt</td>
</tr>
<tr>
<td>44.225.20.199</td>
<td>dmr.db0zm</td>
<td>Service</td>
<td>db0zm</td>
<td>db0nj 439.4375 MHz, Motorola DR30..</td>
<td>269d dl8mbt</td>
</tr>
<tr>
<td>44.225.20.200</td>
<td>proxmox.db0zm</td>
<td>Service</td>
<td>db0zm</td>
<td>Server for Virtual Machines</td>
<td>7m dg8ngn</td>
</tr>
<tr>
<td>44.225.20.201</td>
<td>ipmi.db0zm</td>
<td>Service</td>
<td>db0zm</td>
<td>Remote Console</td>
<td>7m dg8ngn</td>
</tr>
<tr>
<td>44.225.20.202</td>
<td>winxp.db0zm</td>
<td>Service</td>
<td>db0zm</td>
<td>Windows VM</td>
<td>6m dg8ngn</td>
</tr>
<tr>
<td>44.225.20.203</td>
<td>dhcp-44-225-20-203.db0zm</td>
<td>DHCP-Range</td>
<td>db0zm</td>
<td>assigned dynamically</td>
<td>0s system</td>
</tr>
<tr>
<td>44.225.20.204</td>
<td>dhcp-44-225-20-204.db0zm</td>
<td>DHCP-Range</td>
<td>db0zm</td>
<td>assigned dynamically</td>
<td>0s system</td>
</tr>
<tr>
<td>44.225.20.205</td>
<td>wetter.db0zm</td>
<td>Service</td>
<td>db0zm</td>
<td>Wetterstation Davis Vantage Vue -..</td>
<td>102d dl8mbt</td>
</tr>
<tr>
<td>44.225.20.206</td>
<td>netio.db0zm</td>
<td>Service</td>
<td>db0zm</td>
<td>Schaltsteckdose - 1: DMR-Relais D..</td>
<td>269d dl8mbt</td>
</tr>
</tbody>
</table>

18 entries.
## Deployment – Network Documentation Example

### Surrounding subnets:

<table>
<thead>
<tr>
<th>Subnet-IP</th>
<th>Type</th>
<th>Own AS</th>
<th>Parent</th>
<th>Radio parameters / Comment</th>
<th>Edited</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.224.10.0/23</td>
<td>AS-Backbone</td>
<td>-</td>
<td>AS64625</td>
<td></td>
<td>665d dg8ngn</td>
</tr>
<tr>
<td>44.224.10.40/29</td>
<td>Backbone-Network</td>
<td>-</td>
<td>AS64625</td>
<td>db0zm, db0wai - 5825MHz, 10MHz, horizontal</td>
<td>691d dl8mbt</td>
</tr>
<tr>
<td>44.224.10.48/29</td>
<td>Backbone-Network</td>
<td>-</td>
<td>AS64625</td>
<td>db0tvm, db0zm - 5685MHz, 10MHz, horizontal</td>
<td>691d dl8mbt</td>
</tr>
<tr>
<td>44.224.10.72/29</td>
<td>Backbone-Network</td>
<td>-</td>
<td>AS64625</td>
<td>db0zm, db0ebe - 5795MHz, 10MHz, vertikal</td>
<td>691d dl8mbt</td>
</tr>
<tr>
<td>44.225.20.0/22</td>
<td>AS-User/Services</td>
<td>-</td>
<td>AS64625</td>
<td></td>
<td>689d dl8mbt</td>
</tr>
<tr>
<td>44.225.20.192/28</td>
<td>Site-Network</td>
<td>AS65530</td>
<td>AS64625</td>
<td>db0zm</td>
<td>264d dg8ngn</td>
</tr>
</tbody>
</table>

6 entries.

### Surrounding AS:

<table>
<thead>
<tr>
<th>AS</th>
<th>Name</th>
<th>Maintainer</th>
<th>Comment</th>
<th>Edited</th>
</tr>
</thead>
<tbody>
<tr>
<td>64625</td>
<td>DISTRIKT-C-625-AS</td>
<td>dl3mbg, dg8ngn</td>
<td>Oberbayern</td>
<td>567d dl8mbt</td>
</tr>
</tbody>
</table>

1 entry.

### Other sites near db0zm:

<table>
<thead>
<tr>
<th>Site</th>
<th>Name</th>
<th>Distance</th>
<th>Direction</th>
<th>Above ground</th>
<th>Edge</th>
</tr>
</thead>
<tbody>
<tr>
<td>db0tvm</td>
<td>München Olympiaturm</td>
<td>4.4 km</td>
<td>256.2°</td>
<td>200 m</td>
<td>Profile</td>
</tr>
<tr>
<td>dl0muc</td>
<td>Clubstation Chaos Computer C.c.</td>
<td>5.0 km</td>
<td>228.0°</td>
<td>30 m</td>
<td>Profile</td>
</tr>
</tbody>
</table>
Deployment -
Typical User Setup

44.0.0.0/8
HAMNET / AMPRNet

Keep 44.0.0.0/8 for radio amateurs only!

Defaultroute
Deployment – DNS

- Each region can run its own DNS Server
- In Germany there is a national DNS concept in place running under „de.ampr.org“
- The HAMNETDB can generate DNS zone files for downloading

### Generate DNS zone files

- Generate sub-domains for each AS (CGI-parameter: **by_as**)  
  Limit to AS (**only_as**) 

- **SOA-NS** (ns) hamnetdb.ampr.org  
  **SOA-Mail** (mail) hostmaster.hamnetdb.net

- **SOA-Serial** (serial)  
  (Inserted literally, 'unix' > seconds since epoch, default yymmddHHMM)

- Domain-suffix for all entries (**suffix**) de.ampr.org  
  Country (**country**) de

Automated update (Debian file system layout):

```
cd /var/cache/bind &
wget -qO- 'http://hamnetdb.net/dnszone.cgi?by_as=0&suffix=de.ampr.org' | 
tar zxvf - & /etc/init.d/bind9 reload
```

First setup: Add **include "named.conf.hamnetdb"**; to /etc/bind/named.conf.local
Deployment – DNS

- Running a DNS Server is quite some work, so we offer a service to host „HAMNETDB-synchronized“ zones at DB0FHN
- DB0FHN is a DNS-Hub in Germany and will exchange with our other two DNS-Hubs DB0RES and DB0TUD
- At DB0TUD there is a script which synchronizes the *.de.ampr.org information to the flat ampr.org zone
- There is a dataflow diagram of the international distribution of hostname information available
Interconnection with the AMPRNet

- Single Point of Failure: DB0FHN (University of applied sciences Nuremberg)
- Import of IPIP-Routes into the HAMNET
- Registered as a gateway on portal.ampr.org for several subnets

<table>
<thead>
<tr>
<th>Gateway Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Title</strong></td>
</tr>
<tr>
<td><strong>Hostname</strong></td>
</tr>
<tr>
<td><strong>Gateway IP</strong></td>
</tr>
<tr>
<td><strong>Originaly added</strong></td>
</tr>
<tr>
<td><strong>Last modified</strong></td>
</tr>
<tr>
<td><strong>Status</strong></td>
</tr>
<tr>
<td><strong>Subnet 1</strong></td>
</tr>
<tr>
<td><strong>Subnet 2</strong></td>
</tr>
<tr>
<td><strong>Subnet 3</strong></td>
</tr>
<tr>
<td><strong>Subnet 4</strong></td>
</tr>
<tr>
<td><strong>Subnet 5</strong></td>
</tr>
<tr>
<td><strong>Subnet 6</strong></td>
</tr>
<tr>
<td><strong>Subnet 7</strong></td>
</tr>
<tr>
<td><strong>Subnet 8</strong></td>
</tr>
</tbody>
</table>

Notes:
- **gateway area:** Germany, Austria, Switzerland, Luxembourg, Italy (South Tyrol), Spain, Belgium
- **maintained by:** Jann Traschewski, DG8NGN (jann@gmx.de)
- **services:** VPN-Access to AMPRNet and AX.25 via AXUDP, OpenBCM Mailbox, Convers
- **web:** http://db0fhn.efi.fh-nuernberg.de

Extracted from https://portal.ampr.org

- There is even a dataflow diagram of the IP Routing available
AMPRNet: IP-Routing and Data Flow

13.12.2013:
44.16.15.0/24
44.24.192.0/24
44.24.240.0/20
44.74.128.0/24
44.98.254.0/24
44.127.128.0/24
44.130.99.0/24
44.135.120.0/24
44.136.216.0/23
44.136.126.0/23
44.136.150.0/23
44.136.158.0/23
44.136.224.0/24
44.136.227.0/24
44.139.0.0/16
44.140.0.0/16
44.144.0.0/16
44.161.252.0/22
44.169.48.0/20
44.208.0.0/16

"AMPRGW"
169.228.66.252 (amprgw.sysnet.ucsd.edu)
44.0.0.1 (gw.ampr.org, ampr.org)

University of California at San Diego / USA
Gateway-Database (44.x.x.x via <public ip address>),
DNS-Database (see "AMPRNet Routing Information.png")

Direct Connected Gateways
(will announce their 44net block directly to the Internet using BGPv4)
http://www.ampr.org/tos.txt (7b)

Traffic from Internet to AMPRNNet
Mesh-Network encapsulated using protocol number 4 --> see /etc/protocols
(Traffic from AMPRNNet to Internet
Mesh-Network encapsulated using protocol number 4 --> see /etc/protocols
Implementation on Linux using "ip rule"
(Traffic from AMPRNNet to AMPRNNet will be dropped!

Communication only possible if the Direct Connected Gateways take part in the Mesh-Network

Hack:
"Special Gateway" which is not source-route filtered
(avoid routing loops at local gateway using "ip route throw" or "ip route blackhole" of own prefixes)

Mesh-Network using "ipencap" for Peer-to-Peer Traffic
(see "AMPRNet Routing Information.png" to understand the distribution of the Gateway-Database)

IP-over-AX 25 Networks
Wireless Networks
VPN to Endusers

Jann Traschewski, DC8NGN
05.01.2014

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Interconnection with the Packet Radio Network

- DB0FHN connects to the Packet Radio Node "IGATE" (available in the Flexnet based land)

```
DG8NGN: Verbunden mit DB0FHN
<X>NET/LINUX V1.39 Digipeater Nuremberg Institut of Technology. Loc: JN59NK.
Shortcuts: "help", "info", "mailbox", "shell", "admin"
=>c igate

link setup <6>...
*** connected to IGATE
This is IGATE. Internetgatewaysystem for the Packet Radio Network.

Please type "einfo" (english).
Bitte "info" (deutsch) eingeben.
Please type "czinfo" (czech).
Please type "plinfo" (polish).
=>arp

<table>
<thead>
<tr>
<th>IP</th>
<th>Iface</th>
<th>Hardware</th>
<th>Min.</th>
<th>Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.130.60.100</td>
<td>AX25</td>
<td>DBOFHN-10</td>
<td>0</td>
<td>10829</td>
</tr>
<tr>
<td>44.130.90.100</td>
<td>AX25</td>
<td>DBOTUD-10</td>
<td>0</td>
<td>17615</td>
</tr>
<tr>
<td>44.130.254.1</td>
<td>AX25</td>
<td>DG8NGN-10</td>
<td>0</td>
<td>307</td>
</tr>
<tr>
<td>44.130.254.254</td>
<td>AX25</td>
<td>IGATE</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

=>i pr

IP-Routes of 44.130.254.254:

<table>
<thead>
<tr>
<th>IP-Net</th>
<th>M</th>
<th>Iface</th>
<th>via IP</th>
<th>use</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.130.254.0</td>
<td>24</td>
<td>AX25</td>
<td>44.130.90.100</td>
<td>739</td>
</tr>
<tr>
<td>44.130.90.0</td>
<td>24</td>
<td>AX25</td>
<td>44.130.254.254</td>
<td>20979</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>AX25</td>
<td>44.130.60.100</td>
<td>41417</td>
</tr>
</tbody>
</table>
```
Interconnection with the Packet Radio Network

- The allocation for IGATE is 44.130.254.0/24 and is splitted into fixed addresses 44.130.254.1 to 44.130.254.127 (e.g. DG8NGN = 44.130.254.1) and dynamic addresses 44.130.254.128 to 44.130.254.253

- Connect with a Packet Radio Terminal to IGATE via your access digipeateer and type „GETIP“

```bash
DL4HFO: Verbunden mit DBOFHN
SXNET/LINUX V1.39 Digipeater Nuremberg Institut of Technology. Loc: JN59NK.
Shortcuts: "help", "info", "mailbox", "shell", "admin"
=> c igate

link setup <6>...
*** connected to IGATE
This is IGATE. Internetgatewaysystem for the Packet Radio Network.

Please type "einfo" <english>.
Bitte "info" <deutsch> eingeben.
Please type "czinfo" <czech>.
Please type "plinfo" <polish>.
=> getip

Your_Ipaddress: 44.130.254.129

=>
=> arp

<table>
<thead>
<tr>
<th>IP</th>
<th>Iface</th>
<th>Hardware</th>
<th>Min. Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.130.60.100</td>
<td>AX25</td>
<td>DBOFHN-10</td>
<td>0 11028</td>
</tr>
<tr>
<td>44.130.90.100</td>
<td>AX25</td>
<td>DBOTUD-10</td>
<td>0 17677</td>
</tr>
<tr>
<td>44.130.254.1</td>
<td>AX25</td>
<td>DG8NGN-10</td>
<td>0 315</td>
</tr>
<tr>
<td>44.130.254.129</td>
<td>AX25</td>
<td>DL4HFO</td>
<td>57596 0</td>
</tr>
<tr>
<td>44.130.254.254</td>
<td>AX25</td>
<td>IGATE</td>
<td>0 0</td>
</tr>
</tbody>
</table>
```
Interconnection with the Packet Radio Network

- Insert the new IP address in your IP stack and try a ping

- Instructions how to interconnect Packet Radio Nodes (XNet) to the HAMNET or AMPRNet are available
Motivation or „why?“

● The easy answer: „Why not?“
  → „Why?“ is not a valid question in a hobby

● Seriously:
  → Most administrators just want to attach repeaters to the internet. So why not deploying the local network with net44 addresses rather than RFC1918 addresses (10.0.0.0/8, 172.16.0.0/12 and 192.168.0.0/16)?

It doesn't hurt. Just apply for an IP range and use it (even if not interconnected to the AMPRNet, yet).
Motivation – Connection to net44

- Provide and use services on net44
- Trusted network
  - Packets from net44 are supposed to come from an amateur radio operator
  - Providing gateways to RF is OK without further authentication of the individual amateur (e.g. access to the Packet Radio Network, access to shared Remote Transceivers, ...)
- End-to-End communication
  - NAT is evil...
  - No need to struggle around with portforwarding
Motivation – Building a RF backbone

• Backbone for services (cf. Packet Radio Network – BBS, Convers, …)

Transport of:
  – DATV, VoIP (DMR, D-Star, Echolink), Packet Radio
  – whatever you can transport on TCP/IP...

• Build an independent network for emergency communication (where the funding could come from...)

• It is cool - „Because we can...“
Motivation – Learning & Experimentation

• Building your own Internet
  – Technology you usually don't get in touch with (Routing protocols, Server-to-Server VPNs, DNS-Hosting, …)
  – Peering with other groups around the world

• Building your own backhaul
  – GHz wave propagation
  – System Integration of backhaul technology
Application Examples - FM Repeater Group (SVXLink)

- Hansa-Link Network
Application Examples - FM Repeater Group (Allstarlink)

- Link (Süd) Tirol

Kronplatz

Usb Soundkarte

PC + Software

Flatschspitze

Gantkofel

Usb Soundkarte

PC + Software

= Link (Süd)Tirol

Tirol (isch lei oans)
Anwendung - Live-Streaming

Hier wird in einem Flashplayer Live-Stream von Amateurfunkstationen angezeigt. Benutzer können hier ebenfalls ihren eigenen Kanal bekommen. Bitte mit nrwth-atv@online.de Kontakt aufnehmen.
Application Examples – Social Network
Application Examples - Searchengines
Application Examples - WebSDR

http://websdr.org
Application Examples - Webcams

Kronplatz - Bruneck / Pustertal - Blick nach Norden über das Tauferer Tal
27.12.13 21:40  -2.8°C  (f/3.5  25s  iso1600)

http://www.foto-webcam.eu
Todo – More bands

- 9cm: More expensive compared to 6cm/13cm
- 3cm: Ubiquiti PowerBridge M10
  - not much power
  - high price
- 24 GHz: Ubiquiti airFiber AF24
  - short range (license free band)
  - high price
- Selfmade Up-/Downconverter?
  - Full duplex with Mikrotik NStreme Dual possible
    - One card in TX mode
    - One card in RX mode
ToDo – Filters

- 5 MHz bandwidth
  - +/- 20 MHz → own signal seen again (lower level)
  - +/- 40 MHz → own signal seen again (less lower level)

- 10 MHz bandwidth
  - +/- 40 MHz → own signal seen again (lower level)
Todo – Better Routing Protocols

• Most routing protocols doesn't take changing conditions on a radio link into account
  - Packet loss (any kind of reason, e.g. Interference)
  - Changing throughput due to adaptive modulation and coding (AMC)
  - TX-ccq and RX-ccq (Client connection quality)
  → Flapping routes, unreliable connections...

• There are some protocols to test (B.A.T.M.A.N., OLSR, Mikrotik MME)
  - Protocols can be tested within a region, however sometimes communication between two stations might be better routed using a path through an external autonomous system...
  - Routing protocols need to be supported by the platforms
Todo – User Access Technology

- Connectivity more important than speed
- Reduced bandwidth = less noise → longer range
- Lower band = better for non-line-of-sight requirements

**Wishlist**
- 70cm band: 2 MHz, 1 MHz, 500 kHz, **200 kHz**, 100 kHz
- 23cm band: 10 MHz, 5 MHz, 2 MHz, **1 MHz**, 500 kHz, 200 kHz (10 MHz / 5 MHz available from Doodlelabs)

- We already run D-Star DD 128kbit/s User Access on 23cm on net44
ToDo – Access to net44

• Access to network 44 needs to be improved
  – by RF (more sites, more bands, more technology)
  – by VPN (more VPN dial-in gateways)
  – by IPIP (better instructions how to join)
  – by BGP direct connected networks (more material to convince local ISPs to announce net44 networks)

• Access to network 44 needs to be simplified
  – Better instructions
  – Easier ways to connect
  – Better worldwide concept
Vision – Intranet for radio amateurs

• We want to create a huge intranet for radio amateurs using network44
  – Users should be able to provide services for radio amateurs in an easy way (e.g. end-to-end communication to single devices)
    • webcam.dg8ngn.ampr.org
    • web.dg8ngn.ampr.org
    • notebook.dg8ngn.ampr.org
  – The chicken-egg problem will be solved by content on the network
    • Hambook (Facebook for radio amateurs on net44)
    • Interconnected search engines to find content (yacy)
Vision – Authentication platform

• Providing services for radio amateurs on the internet leads always to the same question:

  How can I authenticate radio amateur operators?

• We need a global and easy solution to answer this question for services like:
  
  D-Star, Packet Radio, Access to net44, Echolink, Allstarlink, DX-Clusters, …

• Once we have a global solution more applications with access through the internet will be available due to easy implementation for programmers