February 1994
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Updated October 2001 to reflect subnets used in the UK today by g4apl
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The attached document is a discussion document G8FSL sent to the
National Co-ordinator ages ago. It details what we want to do in
the long-term, and an IP Addressing Scheme that would permit it.
It would takes years to get a multi-level network, so what we're
trying to do is the first step or two.

The proposal was never circulated by the National Co-ordinator,
and so in Southern England we've decided to go ahead as an
experiment, using the spare area of IP numbers in each region.

Please circulate this as widely as you like, since it can't be
discussed unless lots of people see it.

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        IP Addresses for the UK: A discussion document

The current IP addressing scheme (based on RSGB regions) has (at
least) two problems.
Firstly, the number of stations active on TCP/IP has meant that
the address space of some of the regions is starting to become
full: clearly if the interest in TCP/IP increases significantly
there will be problems in allocating addresses (there being only
255 possible addresses per region (reserving ".255" as a
broadcast address).
Secondly, the allocation of addresses within each region has been
in numerical order. This means that two adjacent IP addresses can
be many miles (or tens of miles) apart. This makes sensible
routing tables very difficult to produce (since, within a region,
almost every address will be an exception to almost any routing
rule).

The purpose of this proposal is to attempt to solve these
problems, and to create an IP addressing scheme for the U.K.
which will provide a useful service for a reasonable number of
years.

The proposal is closely connected (and, in fact, driven by) the
"hub" principle that has been proposed in the Home Counties in
recent months.
The hub principle is intended to be the first phase of a plan to
eventually create a TCP/IP packet network within the U.K. It is
probable (and hoped that) that the bulk of amateur packet
activity will slowly move away from "vanilla" AX25 operation
towards a more layered set of protocols providing better and more
sophisticated services. Whilst the protocol set may not be TCP/IP
in the long term, the chosen set will almost certainly evolve
from TCP/IP protocols. Thus the TCP/IP network will quite
possibly provide the bulk of the U.K. network capability in the
future.
The "hub" (or "node", although the latter term is not preferred
as it can be confused with the NET/ROM terminology) is the
network access point for a TCP/IP end-user. Each hub will cover

a small area- encompassing up to perhaps 10 users, operating
(with low power) on a single local frequency.
Each hub within a larger area (county?) will (eventually, as the
network takes shape) be connected to an area hub. The links to
the area hub will be high(er) speed links, and on a frequency
other than that/those used for local access in the area (there
are pros and cons for using a cellular approach to frequency
reuse at the user access level). The area hubs will eventually
be connected by high speed links to regional super-hubs, which
in turn will be linked on dedicated frequencies by a U.K.
backbone at the highest data rates.

The objective of this network is to enhance and simplify the
routing of TCP/IP traffic. Each user would have a routing table
with entries for those local stations which can be reached
directly. Each user's default route would be to the local hub.
Each hub would have a routing table similarly with entries for
local stations/hubs, and a default route to the area hub (with
possible entries to send traffic for neighbouring regions to a
another hub in the right geographical direction). Similarly at
each higher level the default entry would be to send traffic "up
the network", with fixed entries for local routes.
The network would also provide centralised resources. Each local
hub could provide a POP server for mail, thereby obviating the
need for 24 hour a day operation by users. The local hub could
also provide a domain server (updated regularly over the
network), so each user need not hold a large "domain.txt" file.


In order for the routing scheme outlined above to operate, a more
structured approach to the allocation of IP addresses is
required. This is needed so that the "sub-net mask" concept can
be utilised: this is where a specified number of the leading bits
in the IP address are tested for a match, and if matched then a
specified route is used. For example, the command:

route add 44.131.7.0/24 vhf 44.131.19.127

routes all traffic for IP addresses which have the leading
("leftmost") 24 bits matching 44.131.7.0 (i.e. the addresses
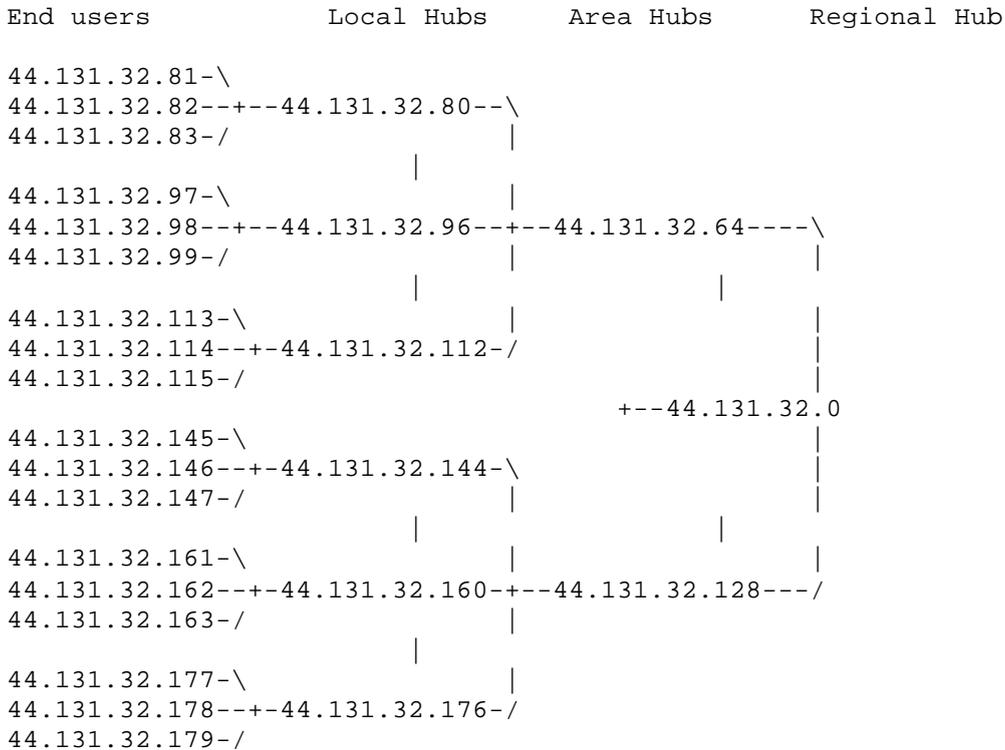44.131.7.<any>) via station 44.131.19.127 on our port "vhf".

Note 1:   "route default" is functionally the same as "route add
          0.0.0.0/0 ...", i.e. match any address.

Note 2:   "route add <address> ...." with no "/<num>" qualifier
          is functionally the same as "route add <address>/32
          ....", i.e. all 32 bits must be matched.

Note 3:   where a given address matches several patterns, the
          pattern with the greatest degree of matching (most
          bits matched) is used. Thus:
          "route add 44.131.7.0/24 vhf 44.131.19.127"
          "route add 44.131.7.5    vhf 44.131.19.129"
          will treat "...7.5" as a special routing case.

```
This feature is the key to the routing of traffic, in that the
"users" of a given level hub have addresses which "lead on" from
that of the hub.
Consider the following example:

End users            Local Hubs     Area Hubs      Regional Hub

44.131.32.81-\
44.131.32.82--+--44.131.32.80--\
44.131.32.83-/                  |
                                |
44.131.32.97-\                  |
44.131.32.98--+--44.131.32.96--+--44.131.32.64----\
44.131.32.99-/                  |                  |
                                |                  |
44.131.32.113-\                 |                  |
44.131.32.114--+-44.131.32.112-/                   |
44.131.32.115-/                                    |
                                      +--44.131.32.0
44.131.32.145-\                                    |
44.131.32.146--+--44.131.32.144-\                  |
44.131.32.147-/                  |                  |
                                 |         |        |
44.131.32.161-\                  |         |        |
44.131.32.162--+-44.131.32.160-+--44.131.32.128---/
44.131.32.163-/                  |
                                 |
44.131.32.177-\                  |
44.131.32.178--+-44.131.32.176-/
44.131.32.179-/
```

```
>From anywhere outside this subnet, each user can be reached by
a "route add 44.131.32.0/24 <port> <gateway>" command.
The regional hub can split the traffic with 2 statements, namely:
"route add 44.131.32.64/26  <port> 44.131.32.64"
"route add 44.131.32.128/26 <port> 44.131.32.128"
The area hub 44.131.32.128 has a routing table which reads (in
its entirety!):
"route add 44.131.32.144/28 <port> 44.131.32.144"
"route add 44.131.32.160/28 <port> 44.131.32.160"
"route add 44.131.32.176/28 <port> 44.131.32.176"
"route default <port> 44.131.32.0"
```

```
Note 1:   The above example has a regular structure, although
          this is not essential.
Note 2:   It would be possible for a single site to encompass
          more than one level of hub.
Note 3:   The apparently missing addresses in the above example
          can be used by stations/hubs outside the regular
          structure.
          E.g. 44.131.32.1 could be the regional hub sysop, and
          44.131.32.65 the sysop of 44.131.32.64.
          44.131.32.32 could be a local hub directly connected
          to 44.131.32.0, as could 44.131.32.16
```

```
(I recommend that the above example is worked through, converting
the addresses into binary. To assist, taking just the third
octet:
Regional hub    Area hub        Local hub       User
00000000        01000000        01010000        01010001
                                                01010010
                                01100000        01100001
                                                01100010
                10000000        10010000        10010001
                                                10010010
                                10100000        10100001
                                                10100010
)
```

Note: It is important to realise that the scheme is flexible, in
that it can cater for situations where there are many users on
few hubs, or few users on many hubs (or, to a certain extent, a
combination of situations within a region or area).


Clearly in order to implement a scheme such as this, the whole
of the U.K. IP address allocation would have to be reworked. This
is not a task to be taken lightly, but the long term benefits
would seem to far outweigh the short term problems.

Practical addressing schemes divide the country into regions. It
must be borne in mind that any radio-based network suffers from
the fact that radio waves are no respecters of county boundaries,
and that whilst a station may be physically located in a given
county, in RF terms the station should be considered to be in a
neighbouring county (or country).
Nevertheless, dividing the country into regions on a county basis
is still probably the most practical method. However, with the
hub scheme proposed it is no longer the location of the
individual station which determines the region, but rather the
location of the local hub to be used. Together with the sub-net
masking of addresses, the best scheme for IP address allocation
would seem to be to devolve the allocation down to the hub
sysops.


In order to maximise the address space for IP addresses in the
U.K., it is proposed to divide the country into 32 regions. The
region number can be held in 5 bits, and the 5 bits used will be
the leading 5 bits in the third octet. This leaves 11 bits for
addressing within the region (the 3 trailing bits of the third
octet, plus the whole of the fourth octet). This would represent
an 8-fold increase in address space over the current scheme if
the individual regions were the same size: it is hoped that the
division into regions will give an additional benefit.

The base addresses of the regions will be:

| | | | |
|---|---|---|---|
| 44.131.0 | 44.131.8 | 44.131.16 | 44.131.24 |
| 44.131.32 | 44.131.40 | 44.131.48 | 44.131.56 |
| 44.131.64 | 44.131.72 | 44.131.80 | 44.131.88 |
| 44.131.96 | 44.131.104 | 44.131.112 | 44.131.120 |
| 44.131.128 | 44.131.136 | 44.131.144 | 44.131.152 |
| 44.131.160 | 44.131.168 | 44.131.176 | 44.131.184 |
| 44.131.192 | 44.131.200 | 44.131.208 | 44.131.216 |
| 44.131.224 | 44.131.232 | 44.131.240 | 44.131.248 |

The proposal for the division of the country into regions is
based on the premise that the number of amateurs running TCP/IP
in a county is a constant proportion of the total population of
that county. Thus if the IP address space is allocated on a
county-based system, then each region should have (roughly) the
same number of users.

The U.K. population, according to the 1992 Whittaker's Almanac,
is broken down as follows:

England   46.2M     Scotland  4.96M
Wales     2.80M     N.I.      1.57M          Total:     55.7M


Based on the above population figures, each of the 32 regions
should have approximately 1.74M people living in it, and the
number of regions should be allocated thus:

England: 26   Scotland: 3    Wales:    2    N.I.:      1

(The Channel Islands and the Isle of Man will be included in the
nearest mainland region).

Considering the individual countries:


                    Northern Ireland:      1 region


                   Wales:       2 regions

With a population of 2.80M, each region should encompass a
population of approx. 1.40M

The breakdown of the Welsh population (from Whittaker's Almanac)
is:
Clwyd          402k          Dyfed          342k
Gwent          432k          Gwynedd        239k
Mid Glam       527k          Powys          117k
South Glam     383k          West Glam      358k

The proposed regions are therefore:
Gwent; West, Mid, and South Glamorgan        1.70M
Clwyd; Dyfed; Gwynedd; Powys                 1.10M

                    Scotland:    3 regions

With a population of 4.96M, each region should encompass a
population of approx. 1.65M

The breakdown of the Scottish population (from Whittaker's
Almanac) is:

| | | | |
|---|---|---|---|
| Borders | 103k | Central | 268k |
| Dumfries and Galloway | 147k | Fife | 339k |
| Grampian | 493k | Highland | 209k |
| Lothian | 724k | Orkney | 19k |
| Shetland | 22k | Strathclyde | 2.22M |
| Tayside | 385k | Western Isles | 29k |

The proposed regions are therefore:

| | |
|---|---|
| Strathclyde | 2.22M |
| Dumfries and Galloway; Borders; Lothian; Fife | 1.31M |
| Central; Tayside; Highland; Grampian; | |
|      Western Isles; Orkney; Shetland | 1.43M |


                    England:    26 regions

With a population of 46.2M, each region should encompass a
population of approx. 1.78M.

The breakdown of the English population (from Whittaker's
Almanac) is:

| | | | |
|---|---|---|---|
| Avon | 920k | Bedfordshire | 514k |
| Berkshire | 717k | Buckinghamshire | 620k |
| Cambridgeshire | 641k | Cheshire | 937k |
| Cleveland | 541k | Cornwall | 469k |
| Cumbria | 487k | Derbyshire | 915k |
| Devon | 998k | Dorset | 645k |
| Durham | 590k | East Sussex | 671k |
| Essex | 1.50M | Gloucestershire | 521k |
| Greater London | 6.37M | Greater Manchester | 2.45M |
| Hampshire | 1.51M | Hereford & Worcester | 668k |
| Hertfordshire | 952k | Humberside | 835k |
| Isle of Wight | 127k | Kent | 1.49M |
| Lancashire | 1.37M | Leicester | 860k |
| Lincolnshire | 574k | Merseyside | 1.38M |
| Norfolk | 736k | Northamptonshire | 573k |
| Northumberland | 301k | North Yorkshire | 699k |
| Nottinghamshire | 981k | Oxfordshire | 554k |
| Shropshire | 402k | Somerset | 459k |
| South Yorkshire | 1.25M | Staffordshire | 1.02M |
| Suffolk | 630k | Surrey | 998k |
| Tyne & Wear | 1.09M | Warwickshire | 477k |
| West Midlands | 2.50M | West Sussex | 693k |
| West Yorkshire | 1.98M | Wiltshire | 553k |

The proposed regions are therefore:
1.    Cornwall,Devon,Somerset (1.93M)
2.    Dorset, Wilts, Avon (2.12M)
3.    Hampshire,Isle of Wight (1.64M)
4.    Surrey, West Sussex (1.69M)
5.    Kent, East Sussex (2.16M)
6.    Greater London 1 (2.12M)
7.    Greater London 2 (2.12M)
8.    Greater London 3 (2.12M)
9.    Essex (1.50M)
10.  Herts, Beds, Bucks (2.09M)
11.  Berks, Oxon (1.27M)
12.  Suffolk, Norfolk, Cambs (2.01M)
13.  Gloucester, Hereford & Worcester, Shropshire (1.59M)
14.  Northampton, Warks, Leics (1.91M)
15.  West Midlands 1 (1.25M)
16.  West Midlands 2 (1.25M)
17.  Lincs, Notts (1.56M)
18.  Humberside, S.Yorks (2.09M)
19.  Derby,Staffs (1.94M)
20.  W.Yorks (1.98M)
21.  N.Yorks, Cleveland (1.73M)
22.  Cumbria, Northumberland, Durham, Tyne & Wear (1.98M)
23.  Lancashire (1.37M)
24.  Merseyside, Cheshire (2.32M)
25.  Greater Manchester 1 (1.23M)
26.  Greater Manchester 2 (1.23M)

In the cases of Greater London, West Midlands, and Greater
Manchester there are several regions covering one county. Each
region is to cover a specific area of the county: London is shown
below as an example (I would prefer the other two cases to be
dealt with by someone with local knowledge.

With 3 regions covering a population of 6.37M, each Greater
London region should encompass a population of approx. 2.12M

The breakdown of the population of Greater London into boroughs
(from Whittaker's Almanac) is:

| | | | |
|---|---|---|---|
| Barking and Dagenham | 140k | Barnet | 283k |
| Bexley | 211k | Brent | 226k |
| Bromley | 282k | Camden | 171k |
| (City) | ??? | Croydon | 300k |
| Ealing | 264k | Enfield | 249k |
| Greenwich | 201k | Hackney | 164k |
| Hammersmith and Fulham | 137k | Haringey | 187k |
| Harrow | 194k | Havering | 224k |
| Hillingdon | 226k | Hounslow | 193k |
| Islington | 155k | Kensington and Chelsea | 128k |
| Kingston upon Thames | 131k | Lambeth | 220k |
| Lewisham | 215k | Merton | 162k |
| Newham | 200k | Redbridge | 221k |
| Richmond upon Thames | 155k | Southwark | 197k |
| Sutton | 164k | Tower Hamlets | 154k |
| Waltham Forest | 203k | Wandsworth | 238k |
| Westminster | 182k | | |

The proposed regions are therefore:
1.    Northern Boroughs:
Hillingdon; Harrow; Ealing; Brent; Barnet; Enfield; Haringey;
Waltham Forest; Redbridge; Barking; Havering              2.38M

2.    Inner London Boroughs:
Hammersmith; Kensington and Chelsea; Westminster; Camden;
Islington; City; Hackney; Newham; Tower Hamlets; Greenwich;
Lewisham; Southwark; Lambeth                              2.13M

3.    Southern Boroughs:
Hounslow; Richmond upon Thames; Kingston upon Thames; Wandsworth;
Merton; Sutton; Croydon; Bromley; Bexley                  1.83M


                        Region Numbering

The proposed scheme for numbering the regions is also designed
for ease of routing. Essentially the plan is to perform a binary
tree structure, splitting alternate levels in the tree by
North/South and East/West. The IP address regions can therefore
be routed according to the leading bit(s) of the third octet. For
example, if the MSB of the third octet is '1' for north and '0'
for south, then a station in Scotland could route traffic for any
address with a third octet value less than 128 to the backbone.

Taking '1' to represent north and west, and '0' to represent
south and east, the proposed split (showing the leading 5 bits
of the third octet in binary) is:

(the geography of the U.K. and the proposed regions don't fall
as neatly as wanted into this plan! In fact, certain of the
decisions that are required to make the splitting scheme work
seem very wrong!)

refer to end of file for update of this information (g4apl October)

```
00000     Kent, East Sussex
00001     Surrey, West Sussex
00010     South London
00011     Central London
00100     Hampshire, Isle of Wight
00101     Cornwall, Devon, Somerset
00110     Wiltshire, Avon, Dorset
00111     Gwent, the Glamorgans
01000     Essex
01001     North London
01010     Cambridge, Norfolk, Suffolk
01011     Hertfordshire, Bedfordshire, Buckinghamshire
01100     Oxfordshire, Berkshire
01101     Leicestershire, Warwickshire, Northamptonshire
01110     West Midlands 1
01111     West Midlands 2
10000     Greater Manchester 1
10001     Greater Manchester 2
10010     West Yorkshire
10011     Lancashire
10100     Shropshire, Hereford and Worcester, Gloucestershire
10101     Dyfed, Powys, Gwynedd, Clwyd
10110     Derbyshire, Staffordshire
10111     Merseyside, Cheshire
11000     Lincolnshire, Nottinghamshire
11001     Humberside, South Yorkshire
11010     Northumberland, Durham, Tyne and Wear
11011     Cumbria, North Yorkshire, Cleveland
11100     Dumfries and Galloway, Borders, Lothian, Fife
11101     Northern Ireland
11110     Central, Tayside, Grampian, "Highlands and Islands"
11111     Strathclyde
```

NOTE: The Channel Islands and the Isle of Man have not been
included within any of the above regions. They have not been
ignored in this study, but the decision of which region most
sensibly fits each case has been left to those with local routing
knowledge.

Andrew Benham, G8FSL

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Updated October 2001 by G4APL as he has never seen and updated version of
the original text published in the past 7 years.

This is what has been used for the past 7 years

128 64 32 16 8

```
11111     248.255      Kent, East Sussex
11110     240-247      Surrey, West Sussex
11101     232-239      South London
11100     224-231      Central London (224-227 North) (228-231 South)
11011     216-223      Hampshire, Isle of Wight, Channel Islands
11010     208-215      Cornwall, Devon, Somerset
11001     200-207      Wiltshire, Avon, Dorset
11000     192-199      Gwent, the Glamorgans
```

```
10111    184-191    Essex
10110    176-183    North London
10101    168-175    Cambridge, Norfolk, Suffolk
10100    160-167    Hertfordshire, Bedfordshire, Buckinghamshire
10011    152-159    Oxfordshire, Berkshire
10010    144-151    Leicestershire, Warwickshire, Northamptonshire
10001    136-143    West Midlands 1
10000    128-135    West Midlands 2
01011    120-127    Greater Manchester 1
01010    112-119    Greater Manchester 2
01001    104-111    West Yorkshire
01000    96-103     Lancashire
01011    88- 95     Shropshire, Hereford and Worcester, Gloucestershire
01010    80- 87     Dyfed, Powys, Gwynedd, Clwyd
01001    72- 79     Derbyshire, Staffordshire
01000    64- 71     Merseyside, Cheshire
00111    55- 63     Lincolnshire, Nottinghamshire
00110    48- 55     Humberside, South Yorkshire
00101    40- 47     Northumberland, Durham, Tyne and Wear
00100    32- 39     Isle of Man, Cumbria, North Yorkshire, Cleveland
00011    24- 31     Dumfries and Galloway, Borders, Lothian, Fife
00010    16- 23     Northern Ireland
00001     8- 15     Central, Tayside, Grampian, "Highlands and Islands"
00000     0-  7     Strathclyde
```